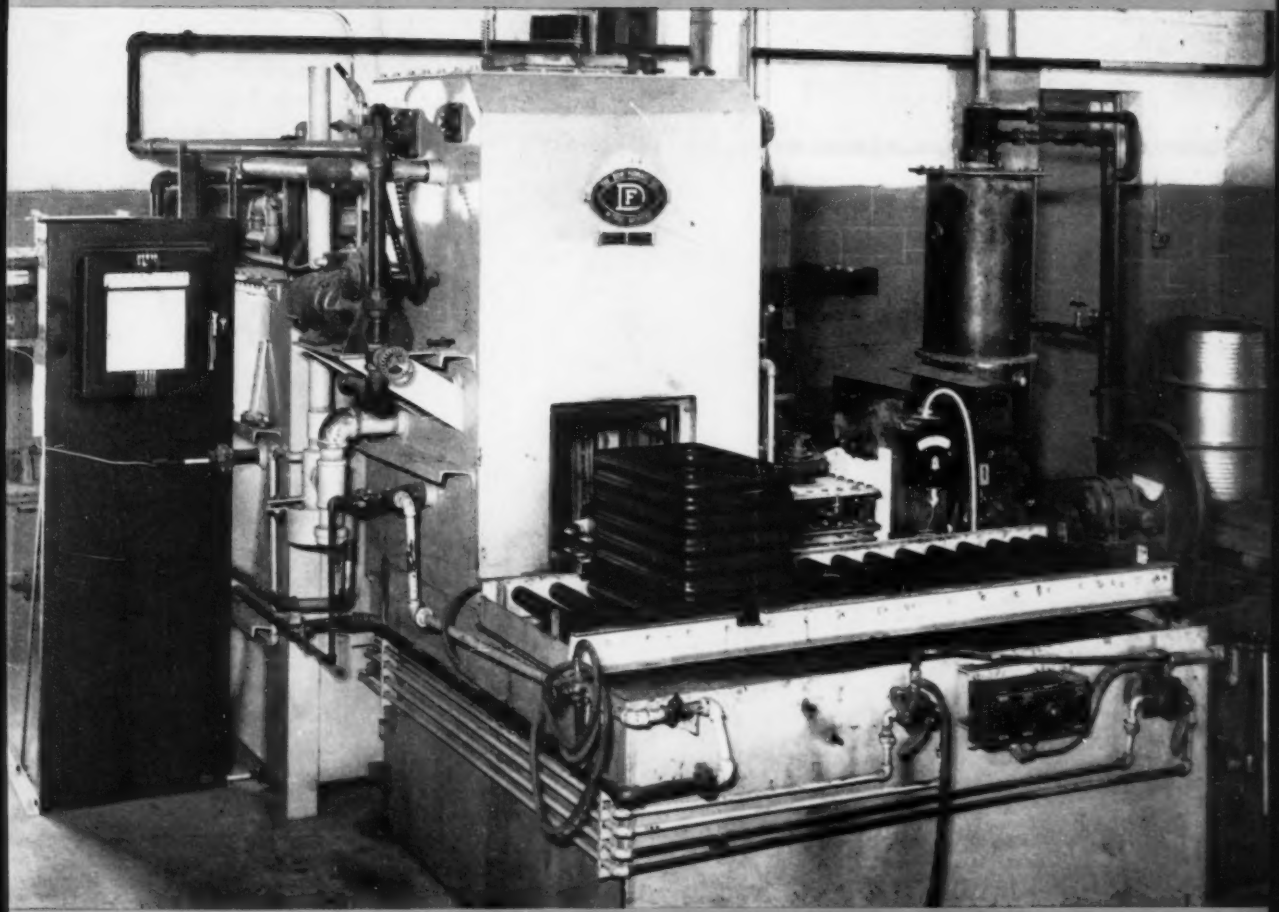
May-June 1956

METAL TREATING

An example of controlled atmosphere furnace equipment which is gaining increasing importance in the heat treating industry. (See page 8). *Photo courtesy of Dow Furnace Co., Detroit, Mich.*



THE *Only* MAGAZINE DEVOTED EXCLUSIVELY TO THE HEAT TREATING INDUSTRY

HOLDEN INDUSTRIAL FURNACES

and

METALLURGICAL PRODUCTS

These new and revised bulletins are available:

- No. 200 Holden Salt Baths and Their Uses.
- No. 201 Holden Pot Furnaces.
- No. 203 Rubber Mold Cleaning, Paint Removal and Desanding Equipment.
- No. 204 Pressure Nitriding Process.
- No. 205 Industrial Furnaces—Gas, Electric and New Luminous Wall Firing.
- No. 206 Austempering-Martempering.

(Free Literature)

Write for any of the above literature in which you may be interested, without obligation, of course.

Holden Metallurgical Products give you more for your money, require less supervision, have proven performance and proven guarantees.

THE A. F. HOLDEN COMPANY

THREE F.O.B. POINTS—LOS ANGELES, DETROIT and NEW HAVEN

P. O. Box 1898	4700 East 48th St.	14341 Schaefer Highway
New Haven 8, Conn.	Los Angeles 58, Calif.	Detroit 27, Michigan

MASTER CRAFTSMEN
METAL TREATING INSTITUTE

Vol. VII No. 3

MAY-JUNE

★ ★ ★

★ ★ ★

Published by the Metal Treating Institute, 271 North Avenue, New Rochelle, N. Y. Phone NE 6-4658.

Indexed in Engineering Index

BPA

Member of Business Publications Audit of Circulation Inc.

EDITORIAL

More Accurate Evaluation of Hardenability Data

The many uses to which hardenability data are put in projecting various design and workability characteristics of steels have always made it important that figures achieved for hardenability be properly analyzed.

End-Quench Tests, while generally satisfactory, can become misleading in their results when the steel is carburized to a high level. The carbon content then becomes a variable element, and concise and definite understanding of results is more difficult.

With the development of the Iso-Hardness Diagram as described by authors Gurley and Hannewald of the Chrysler Corporation in their article on page 2, a method has now been found which will enable the metallurgist to provide hardenability figures whose significance will be more uniformly accurate. To the design engineer projecting a product and specifying steels based upon their ultimate reaction to hardness treatments, this will prove to be of real importance.

The metalworking industry has taken another step forward because the development of this Iso-Hardness Diagram provides an additional and effective tool which will increase the understanding of the design and engineering characteristics of materials and aid in the scientific selection of them.

C. E. Herington

CONTENTS

DEVELOPMENT AND APPLICATION OF THE ISO-HARDNESS DIAGRAM

By **A. E. GURLEY and C. R. HANNEWALD**
Chrysler Corporation
Detroit, Michigan

THE usual procedure employed for the presentation of hardenability data is a plot of hardness vs. end quench distance for a steel with constant carbon content. Certain difficulties arise when the same procedure is applied to carburized hardenability data. These difficulties are emphasized when the end quench bar is carburized to a high carbon level. The only factor considered in studying the hardenability of a sample with uniform carbon content is the variable cooling rate and its effect on hardness. In the carburized sample, the additional factor of variable carbon is introduced. The end quench bar is designed to provide all the necessary information provided suitable means are found for presentation and interpretation. Current methods of presentation do not clearly evaluate the separate and combined effect of carbon, cooling rate, and hardenability on hardness.

The objects of this article are:

A. To provide a method for clearly evaluating carburized hardenability data.

B. To discuss some practical applications of the hardenability concept as described by Iso-Hardness Diagrams.

Experimental Procedure and Results

The steel used in this investigation was AISI 4028 of the following analysis:

Carbon	0.27%
Manganese	0.82%
Silicon	0.27%
Chromium	0.02%
Nickel	0.02%
Molybdenum	0.24%

The material was fine grained (grain size 7) as determined by the McQuaid Ehn grain size test.

Preparation of Test Samples

The material as received, was 1-½" hot rolled bar stock. This carburizing grade of steel was normalized at 1700°F (925°C) for three hours and air cooled. Three end quench bars one inch in diameter by three inches in length, and two carbon concentration bars, one inch in diameter by six inches in length, were machined from the normalized stock. Two end quench bars were plated on the quenched face with 0.0005" of dense copper. Two parallel flats 0.015" deep were ground on each bar utilizing a wet wheel surface grinder. The remaining end quench bar was used for determining the hardenability of the parent steel. The two concentration bars were finish machined with centers to facilitate the sampling for carbon analysis.

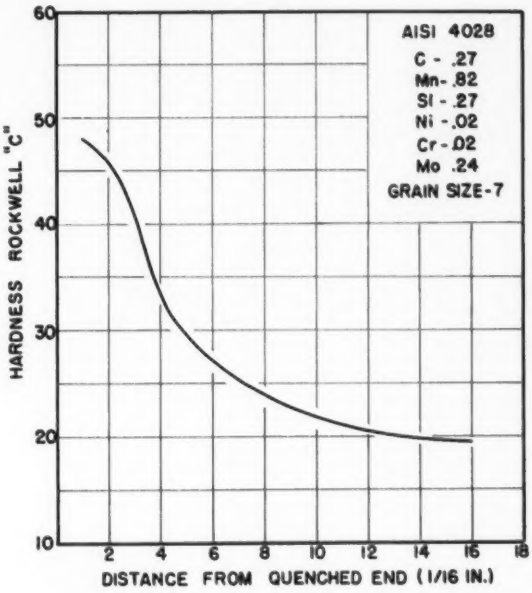


Fig. 1—The core hardenability of AISI 4028.

The End-Quench Test for the Hardenability of Steel as outlined in the ASTM Standards (1952) was followed. Results are presented in Figure 1.

Heat Treating End Quench and Carbon Concentration Bars

The test samples were carburized at 1700°F (925°C) in a six lane continuous carburizing furnace at the Lynch Road Gear and Axle Plant of Chrysler Corporation. The cycle utilized was approximately 13-2/3 hours as adopted for the production of rear axle drive pinions. Two trays of a central lane were loaded as follows:

A. One end quench bar
B. One carbon concentration bar
C. Five production pinions

The location of the specimens was such as to facilitate handling in their removal from the furnace. Upon completion of the carburizing cycle the bars were processed as follows:

A. End Quench Bars—quenched in portable end quench tank for twelve minutes (minimum time)
B. Carbon Concentration Bars—oil quenched five seconds, sand cooled.

These handling operations were completed within twenty seconds.

Collection of Carburized Hardenability Data

The two flats previously ground on the end quench bars were again ground on a wet surface grinder. The amount removed was 0.001". After grinding, 10Kg Vicker hardness readings were taken along the flats at intervals of 0.050". These readings started at the 0.050" distance from the quenched end continuing to the one (1.000) inch distance. Hardness readings were recorded for both flats, averaged, and converted to Rockwell "C" readings. The original flats were again ground and hardness readings repeated. Thus, the hardenability was determined at the surface (approximately) and at 0.010" intervals below the surface until the hardenability of the parent steel was approximated. This procedure was followed for both carburized end quench bars.

Determination of Carbon Gradient

The carbon gradient of the concentration bars was determined by chemical analysis. The samples for analysis were prepared on a turret lathe by step turning to the predetermined depths. The first sample was collected from a 0.002" (0.004" diameter) depth cut. Each succeeding cut was taken to a 0.005" depth (0.010" diameter).

Comparative checks were made on the duplicate concentration bars by two laboratories and the results averaged. These results were plotted by using the mid-point of each cut as the representative location of the sample. (See Figure 2.) The green specimens were finish ground to 1.000" (±0.001"). After

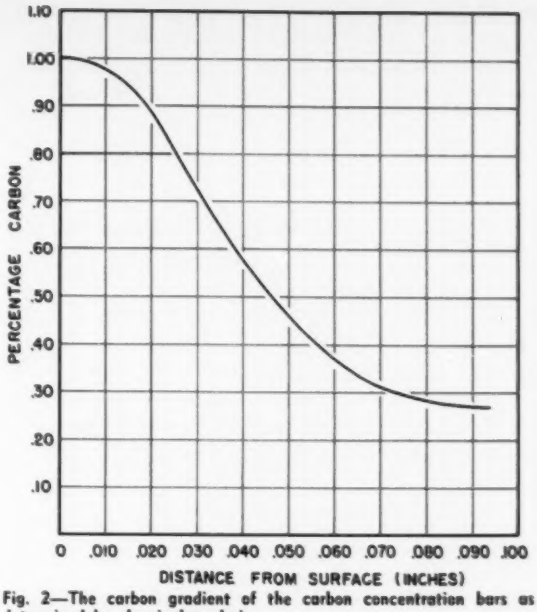


Fig. 2—The carbon gradient of the carbon concentration bars as determined by chemical analysis.

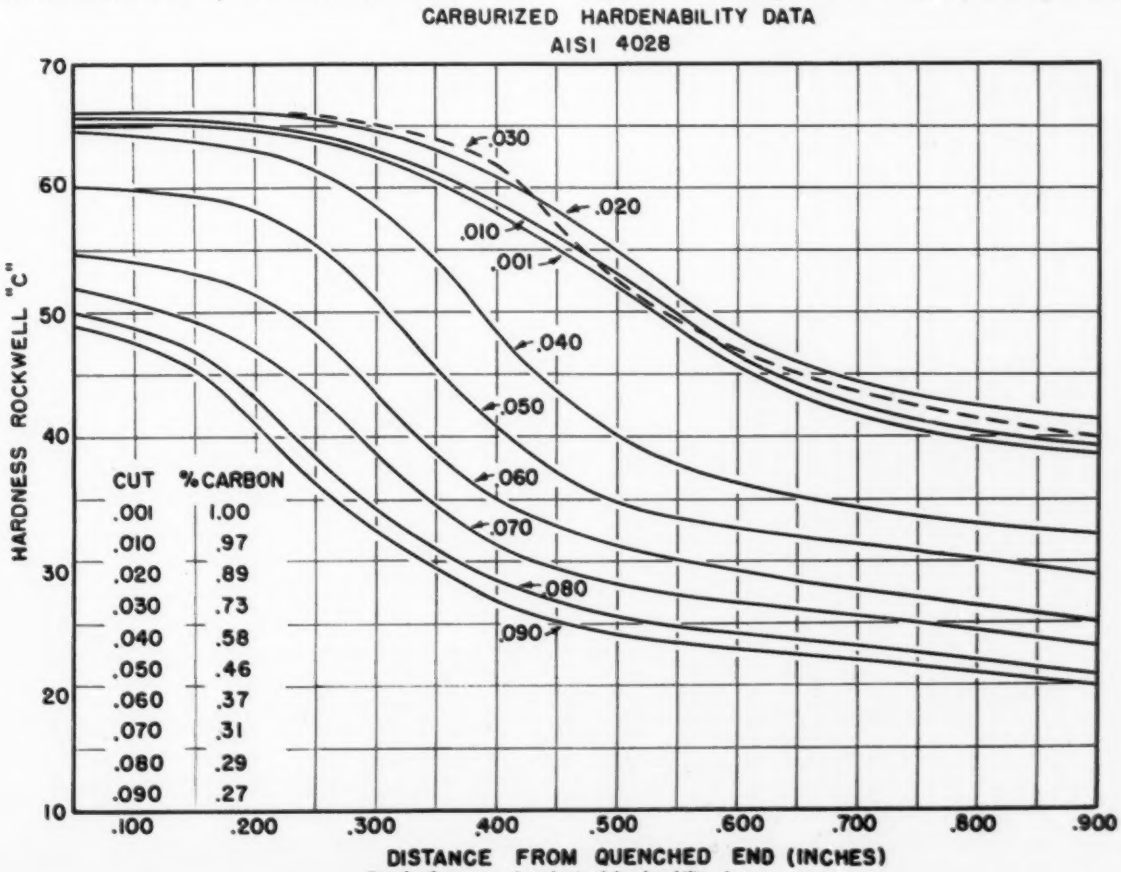


Fig. 3—Summary of carburized hardenability data.

carburizing and cooling, the samples were machine straightened to ±0.001". In sampling ±0.001" eccentricity and runout was permitted. Checks were made using a micrometer after each cut during the sampling.

Development of Iso-Hardness Diagram

Two fundamental assumptions which were proven to be essentially correct are necessary for the interpretation of the carburized hardenability data. These are:

1. Equal cooling rate for equal end quench distances.
2. Equal carbon for equal depth cuts.

Such assumptions allow a cross sectional study at some specified end distance which permits an evaluation of the effect of the variable carbon at a constant cooling rate. Also, the effect of cooling rate on hardness can be determined by studying a specific depth cut which corresponds to a constant carbon level.

Based on the data collected, hardness vs. quench distances may be plotted for each depth cut. The percentage carbon for the various depths can be tabulated or written on the respective curves. (See Figure 3). The inter-relationship of the three factors involved (carbon, cooling rate, and hardness) is not clearly portrayed. As a result, proper interpretations are difficult to make.

The same information may be represented by a three dimensional figure. The third or Z-axis was introduced representing depth of cut or carbon content. (See Figure 4). The Y-axis represents hardness, and the X-axis represents cooling rate or end quench distance. All three factors involved are now portrayed.

Three dimensional figures are difficult to construct and read, and simplification is necessary. A plane constructed parallel to the XY-axis at the 60 Rockwell "C" point will intercept the respective hardenability lines for all cuts up to 0.050 of an inch. The points of intersection may be projected perpendicular to the XY plane. By connecting these projected points, the Rockwell "C" 60 iso-hardness line can be constructed and is defined by percentage carbon and cooling rate. The same procedure is followed in the construction of the various constant hardness lines. The above discussion suggests a simple method of plotting massive carburized hardenability data on a plane figure showing the effect of the three variables.

The simplicity of constructing the "Iso-Hardness Diagram" for carburized hardenability data is illustrated in Figure 5 by tabulating the percent carbon and corresponding hardness at horizontally spaced intervals for each cut. Connecting the constant hardness points defines the iso-hardness line. Figure 6 is a completed "Iso-Hardness Diagram" for the data presented.

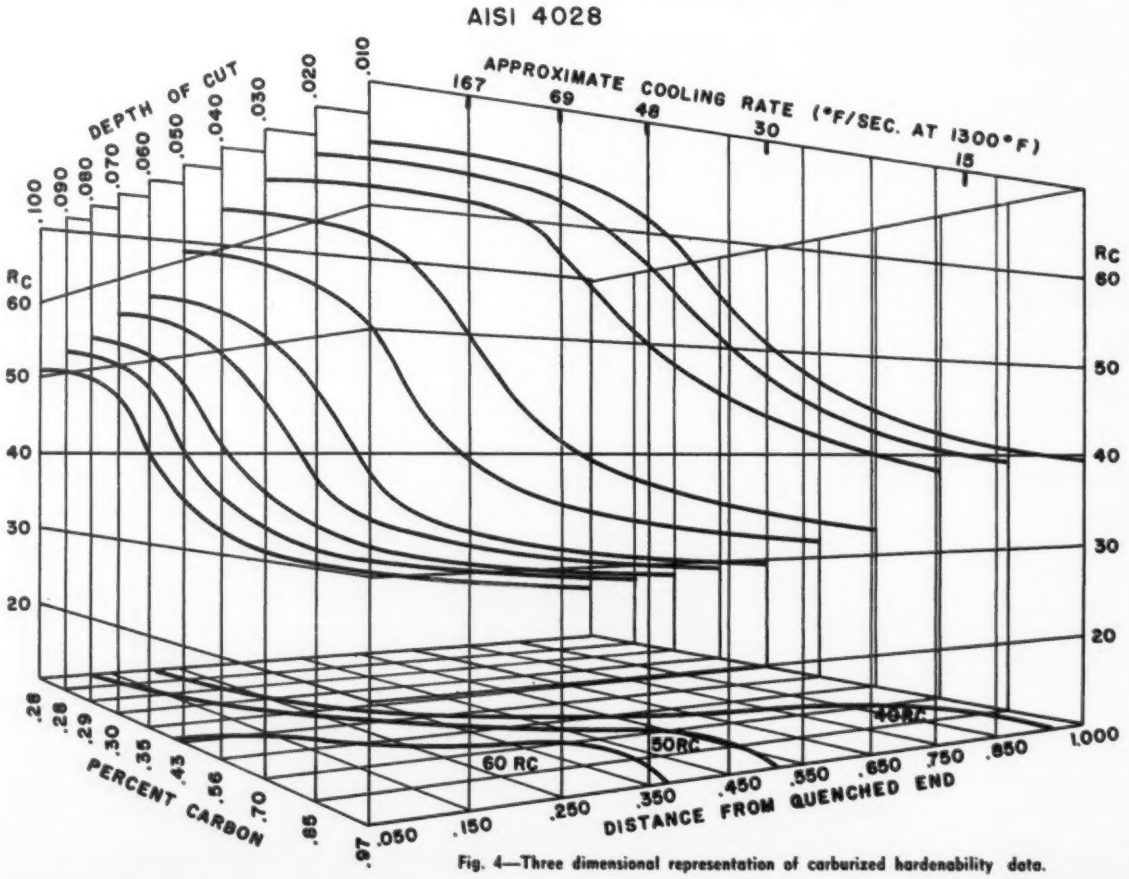


Fig. 4—Three dimensional representation of carburized hardenability data.

	END QUENCH DISTANCE - (INCHES)																			
% C.	.05	.10	.15	.20	.25	.30	.35	.40	.45	.50	.55	.60	.65	.70	.75	.80	.85	.90	.95	1.00	Depth (inches)
1.00	65	65	65	64	63	62	60	57	55	52	49	45	43	42	41	40	39	38	38	38	.001
.97	65	65	65	65	64	63	62	59	57	53	49	47	47	42	41	41	40	39	38	38	.010
.89	66	66	66	66	65	64	63	61	58	55	52	48	46	44	43	43	42	41	40	39	.020
.73	66	66	66	66	65	65	64	62	57	53	49	47	45	44	43	42	41	40	39	38	.030
.58	65	64	64	63	62	58	55	48	45	40	38	37	36	35	34	33	33	32	31	30	.040
.46	60	60	59	58	55	51	45	41	37	35	34	33	32	32	31	31	30	29	28	28	.050
.37	55	54	53	52	48	44	38	35	33	31	30	29	29	28	27	26	26	25	25	24	.060
.31	52	51	49	47	44	39	34	31	29	28	27	27	26	26	25	25	24	24	23	23	.070
.29	50	49	47	43	38	34	31	29	27	26	25	24	24	23	23	22	22	21	21	20	.080
.27	49	47	46	41	36	33	29	27	25	24	24	23	22	22	21	21	21	20	20	19	.090

Fig. 5—An illustration showing the simplified "Iso-Hardness Diagram."

Iso-hardness lines are plotted as a function of percentage carbon and end quench distance.

The hardenability of the parent steel is presented on the iso-hardness chart by two methods. First, a Di value appears in the lower left hand corner based on chemical analysis and a grain size of 7. The method of calculation used was the slide rule calculation developed by U.S. Steel Corporation. The second method which presents the hardenability of the parent steel is a direct plot. The hardness at the intersection of each iso-hardness line and the 0.27 carbon level gives the hardness values at definite end quench distances. These values approximate actual hardenability results as plotted in Figure 1 for the steel studied. The variation which resulted is considered insignificant and could result in converting from Vickers to Rockwell "C" hardness.

Discussion of Results

The central theme of the developed diagram is hardness. The factors considered which affect hardness are cooling rate, added carbon and hardenability. The hardness of a martensitic structure is dependent upon the carbon retained in solution. Likewise, the amount of carbon retained in solution is dependent upon the hardenability of the steel involved and the speed of the quench or cooling rate. These factors operate within limits and their effects are clearly defined in iso-hardness diagrams. A better understanding can be gained by studying specific examples. In reference to Figure 3, the 0.030" depth corresponds to 0.73% carbon. This percentage carbon and the hardenability are assumed constant for the stated cut. The only variable is the cooling rate and hardness is dependent directly upon this variable. The following end quench distances and hardnesses may be tabulated:

End Quench Distance	*Hardness*
.100	66
.200	66
.300	65
.400	62
.500	52
.600	47
.700	43

It is obvious from the above tabulation that maximum hardness is obtained at a critical cooling rate. Increasing the cooling rate above this critical value does not result in an increase in hardness. However, between the end quench distances of 0.300" and 0.700" the hardnesses obtained are dependent solely upon cooling rate.

This procedure may be applied in studying the effect of carbon on hardness. It is assumed that the cooling rate is constant for any specified end quench distance. Referring to the Iso-Hardness Diagram, Figure 6, and the end quench distance of 0.400", the following results are obtained:

Percentage Carbon	*Hardness*
.31	30 R "C"
.37	35
.45	40
.52	45
.58	50
.63	55
.69	60
.85	62 (estimated)
.93	60

Thus, the graphic presentation serves to illustrate that hardness is a function of carbon, increases to a maximum, and further carbon addition is of no value from a hardness standpoint. As indicated, carbon addi-

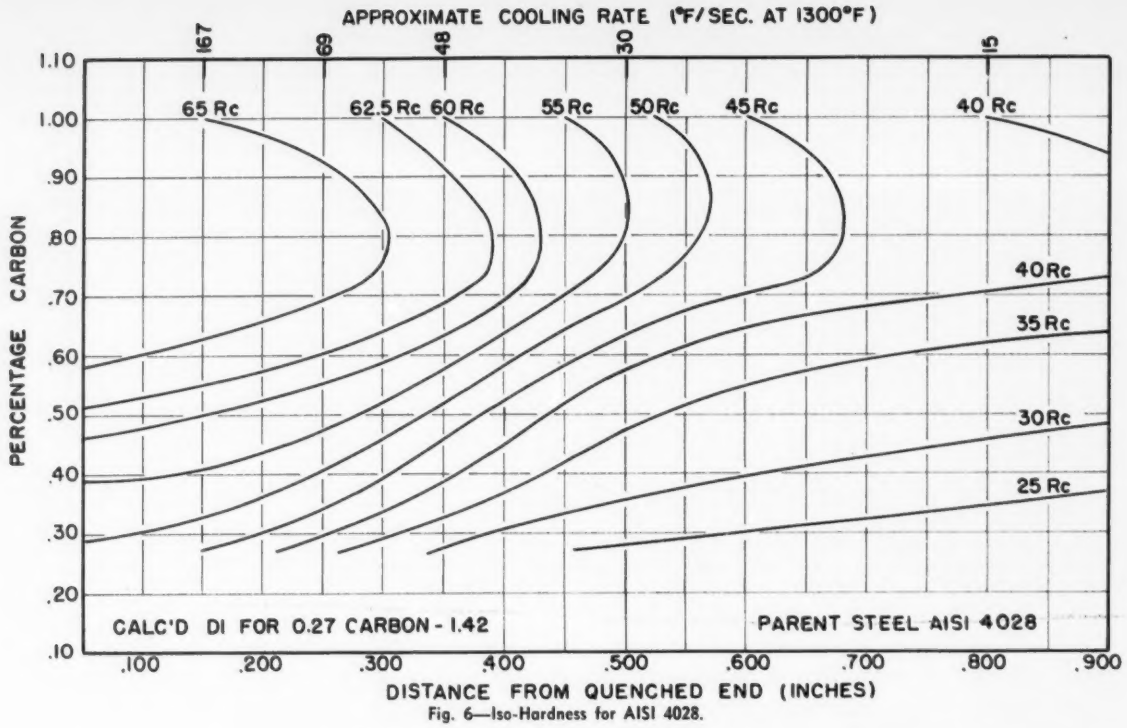


Fig. 6—Iso-Hardness for AISI 4028.

tions above the optimum level (.85% carbon) results in a lower hardness at the end quench distance of 0.400". This decrease in hardness is due to retained austenite for the faster cooling rates. Carbon additions above the optimum level also result in a lower hardness at relatively low cooling rates. In these cases, the decrease is due to retained austenite transformation products, or their combination.

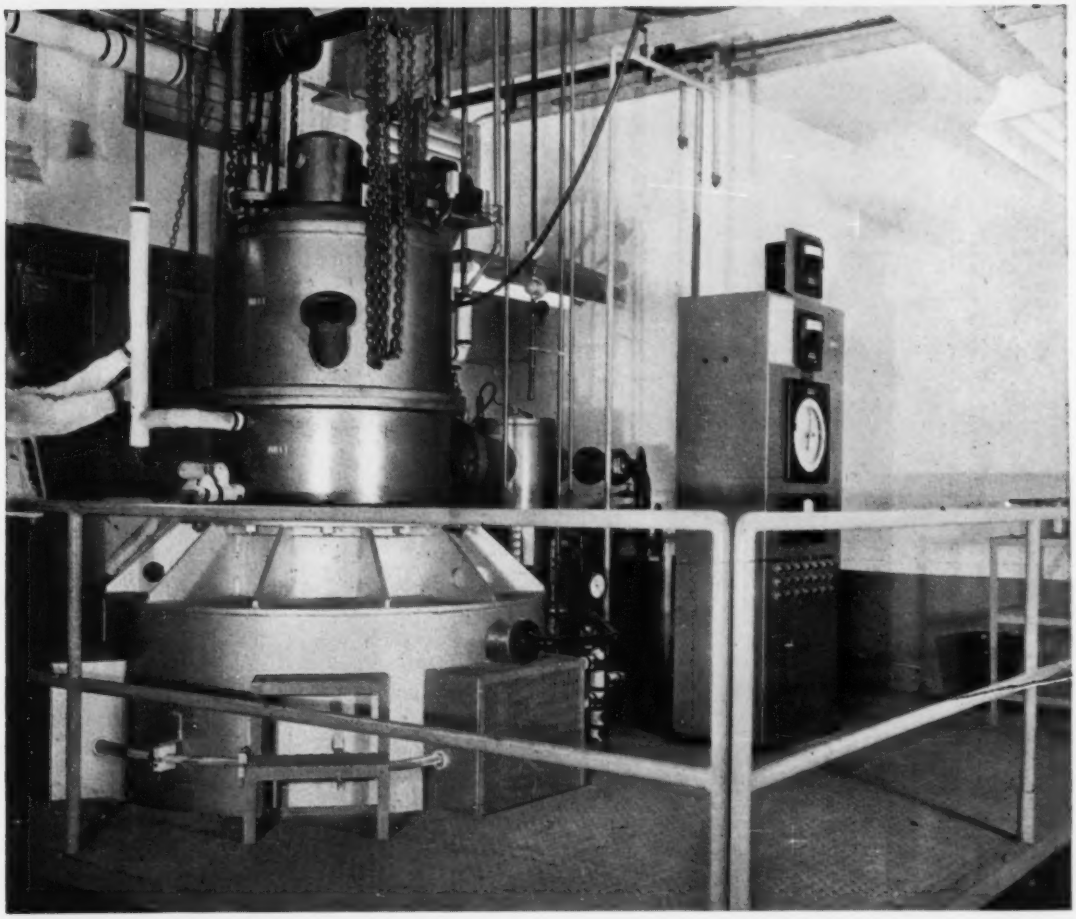
The effect of added carbon on hardenability may also be studied by utilizing the Iso-Hardness Diagram. This may be done by selecting a constant hardness line and noting the effect of carbon on the end quench distance or cooling rate. For example, 55 Rockwell "C" for 0.39% carbon occurs at the 0.050" end quench distance. With an increase in carbon, a slower cooling rate will produce 55 Rockwell "C". The slowest rate occurs at approximately .85% carbon and the 0.500" end quench distance. Increasing the carbon above this percentage fails to increase the hardenability.

Discussion of Applications to Production Practice

The utilization of information obtained by laboratory techniques to production practices usually presents a problem. This is emphasized when carburized hardenability data is considered because of an added variable. However, the degree of difficulty encountered depends upon the accuracy of the information obtained, a correct analysis of the problem, and upon the method of presenting test data.

Useful hardenability data of a heat of steel may be obtained from the end-quench test. The accumulation of this information on the different heats used provides a log of data which enables the Metallurgist to compare equivalent cooling rates and their corresponding hardnesses. This is necessary, for example, in predicting and controlling core hardnesses. The control of the surface hardness and hardness gradient on a carburized and hardened part is required in order to produce a case of consistent quality. The hardness obtained in the case cooled at a constant cooling rate is dependent upon the carbon content and the hardenability of the parent steel. This operates within limits portrayed on the Iso-Hardness Diagram obtained from the carburized end-quench data. The effect of added carbon on hardness depends upon the specific analyses and family of steel used. For this reason, it becomes necessary to collect carburized hardenability data on the same type of steel as used in production practice. The hardenability of the carburizing grades of steel is increased with added carbon. This effect continues until a peak or maximum is reached (see Figure 6). This peak defines for the operator the surface carbon required for maximum hardness and hardenability in the type of steel being used and occurs at approximately 0.85% carbon for AISI 4028. The addition of carbon beyond this point may become detrimental and result in a low surface hardness. The information regarding the most desirable surface carbon for a carburized part is easily obtained from the Iso-Hardness Diagram by locating the percentage of carbon associated with the peak effect.

(Continued on page 32)



Costs and rejections fall substantially, thanks to this new degassing and annealing furnace with its Inconel nickel-chromium alloy retort. Using no gas atmosphere, the unit removes danger of explosions, yet its degassing capacity speeds output. Installed in plant of Raytheon Mfg. Co. Developed by High Vacuum Equipment Corp., Hingham, Mass.

Inconel retort gives safe service in high-vacuum heat treatment

HERE'S ONE OF THE FIRST large-scale vacuum heat-treating installations in the electronic field. This unit degasses steel rings for use in special-purpose power tubes.

It develops such high temperature and vacuum together that the steel readily releases impurities. Particularly gases which can spell failure if emitted during tube operation.

INCONEL the answer

Holding a vacuum of 5×10^{-4} mm Hg for 6 to 8 hours at 1850° F calls for a vessel combining great strength and heat resistance. Operators seal the work in a retort fabricated entirely of Inconel* nickel-chromium alloy.

This alloy resists damage by oxidation and carburization. It combats hydrogen embrittlement, scaling and other corrosive effects. Structurally and mechanically, Inconel nickel-chromium alloy is stable. It provides high load-carrying capacity and creep strength. In addition, it withstands thermal shock without spalling.

Readily fabricated

Measuring 48" in length with an inside diameter of 36", and made of plate 3/8" thick, this retort shows how well Inconel nickel-chromium alloy responds to fabrication. You can form, machine and weld Inconel. And it's available in all commercial wrought forms.

Write for the useful, free booklet, "Keep Operating Costs Down as Temperatures Go Up." Inconel may save you money, so write for your copy now.

*Registered trademark

The International Nickel Company, Inc.
67 Wall Street New York 5, N. Y.

Inconel

INCO TRADE MARK **Nickel Alloys**

. . . for long life at high temperatures

CONTROLLED ATMOSPHERE HEAT TREATING AND EQUIPMENT

Editor's Note: *This is the concluding installment of the article, Part I of which appeared in the March-April issue.*

By **F. E. HARRIS**
The Dow Furnace Co.
Detroit, Michigan

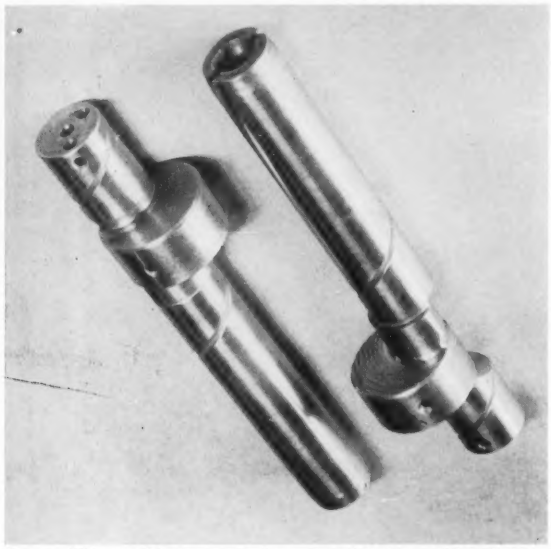


Fig. 6—This crankshaft presented a severe distortion problem because of its non-uniform cross section.

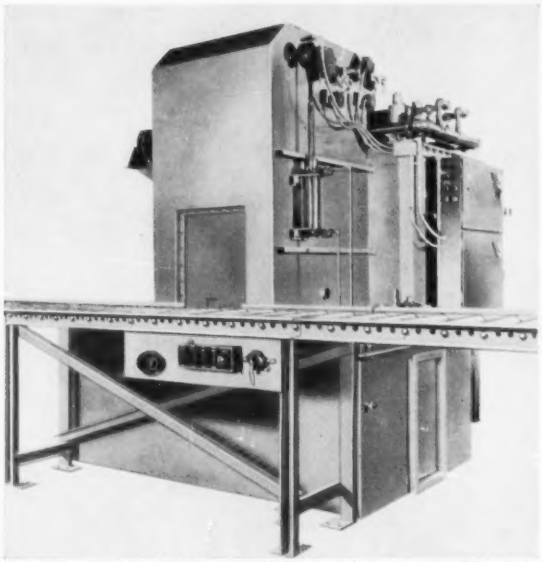


Fig. 7—Dow Model J-800 controlled atmosphere furnace. This is a production furnace based on the design illustrated in Part I, Fig.1

An Atmosphere Heat Treating Operation

In Part I of this article, the problems encountered in various portions of the heat treating cycle were our chief concern. Now it may be instructive to take a specific metallurgical problem and correlate operational methods and specific equipment constructions with the metallurgical requirements.

A 7/8" diameter by 7" long shaft (Fig. 6), forged with an eccentric cam located 1½" from one end is to be treated in a semi-finished condition. The steel specification is SAE 1020, and the problem is one of processing without a straightening operation such that a finish grind provides a true surface of R "C" 60 hardness. This is a distortion problem and careful loading as well as an interrupted quench in marquenching oil along with temperature and case considerations combine to provide an interesting cycle.

Quenching considerations dictate horizontal loading with the shafts in rows, adjacent shafts being reversed with the cams on the side. The base tray, approximately 20" wide by 30" long, is fitted with three telescoping containers, each container carrying three rows high of 56 shafts each, each row being separated by an expanded metal screen. The complete load consists of 504 shafts weighing 1¼ lb. each plus tray and containers weighing 170 lbs. for a total gross weight of approximately 800 lbs. The containers are each 6" high or 18" in combined height, for a total volume of approximately 6 cubic feet. Neglecting the weight of the separating screens, we have a uniformly loaded charge with a load density approximately:

$$\frac{504 \times 1\text{-}\frac{1}{4} \times 100}{6 \times 480} \text{ or } 22\%$$

The particular unit we are about to describe, (Fig. 7), employs three boxes for the cycle, and since the quenching, reloading, and discharging occur in a relatively short time cycle, we may start the cycle description with one container loaded and outside the unit, one in the upper station of the lowerator with the double lowerator in the up position, and one in the heating chamber. Both doors are closed, and container three is ready for the quenching operation, although it has yet to be removed from the heating chamber.

Let us begin with the sealed furnace where the vestibule is filled with gases fed from the heating chamber. The outer door slide is opened, the inner door is raised, the container is transferred to the lower section of the lowerator, and the lowerator

descends into the quench. Immediately, the container on the upper section, now in line with the high heat rolls, is charged into the heating chamber, and the inner door is closed. The total empty furnace time has not exceeded 30 seconds.

We have protected the hot container during this operation, since the expansion of the vestibule gases has caused a pressure increase in the vestibule. However, we are now confronted with a contraction, since the vestibule no longer has the hot load and the inner door is closed, causing a rapid drop in temperature of the vestibule gases. This contraction of volume draws air through the slide opening on pressure equalization where it burns at the pilot flame front. Thus, the expansion of gases on burning equalizes the vestibule pressure quickly. The pressure relief valve is closed during this contraction period since the pressure in the vestibule is now atmospheric, and although we have contaminated the vestibule gases, there is no air in the cold vestibule due to the ignition of the mixture at the slide opening.

Realizing that the lowerator is in the down position, with a container in the quench, let us consider the remainder of the container movements. Allowing three minutes to elapse after immersion in the quench (sufficient for this section and treatment), the outer door is opened, the green container is rolled onto the upper lowerator section and the lowerator is raised. The quenched tray is discharged through the open door, purge gas is introduced into the vestibule, the outer door is closed, and the slide in the door is also closed. Within a few seconds (a fast purge rate of natural gas is employed), a flame appears at the small port in the slide, the purge gas is discontinued, and the entire quenching, charging and discharging cycle is completed.

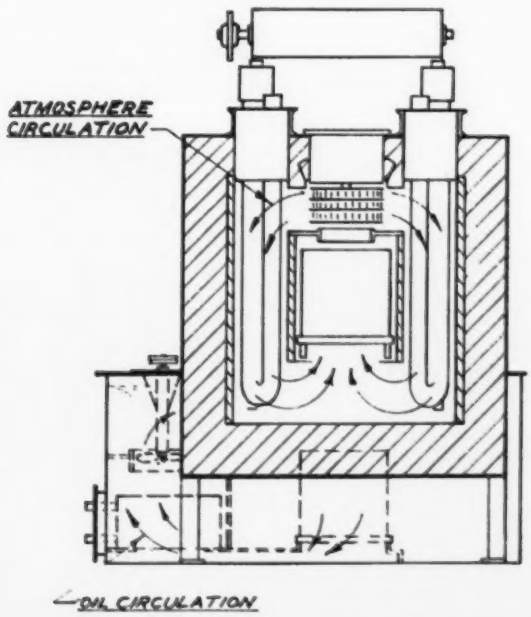


Fig. 8—Cross section of furnace chamber of the Model J-800 unit.

The container which has been charged in the heating chamber is now the important one, and we will follow it through the heating cycle and the quench, and having covered the vestibule operations, let us consider Fig. 8 which illustrates another section of the heat treating unit. The furnace is heated by four vertical return bend radiant tubes, two on either side, and the heat storage and the directional flow for the gas circulation is provided by the tile construction surrounding each of the heating tubes. An endothermic generator of the catalytic type is incorporated in the furnace, and consists of 2½" alloy tubes mounted concentrically in each of the radiant tube firing legs. Each of these small tubes is filled with nickel impregnated brick catalyst, and is supplied with a constant flow of an accurately controlled mixture of air and natural gas at a mix ratio of 2.50:1. The small tube diameter allows the reaction to complete itself at a comparatively low temperature since the heat distribution factor varies inversely with the square of the diameter. This method of gas supply has the merit of supplying hot carrier gas to the chamber and thus aids the heating process over that of carrier gas additions at room temperature, as with gas prepared in an external generator.

A four-hour time cycle is proposed for the treatment. One hour is used to bring the charge to the carburizing temperature, 1625°F., where 30 minutes are required to reach a temperature 100°F. below the treatment temperature and 30 minutes to complete the temperature attainment due to the action of the heat capacitor. A case depth of .030" is required to meet the hardness requirement after finish grinding, and with an attainment of .019" for the first hour the time at 1625°F. becomes $\left(\frac{.030}{.019}\right)^2$ or 2½ hours.

To increase the depth of hardening, ammonia will be supplied along with methane for carbon supply, and for the supply purposes, a rate of 15 c.f.h. for methane (or natural gas) and 10 c.f.h. for the ammonia is maintained throughout the heating and carbon-nitrogen addition periods.

We have used 3½ hours of our four-hour cycle, and the remaining 30 minutes will be used in reducing the as-quenched temperature of the charge. This lower temperature prior to quenching aids distortion control and favors final hardness characteristics. The quench temperature is 1525°F., 100°F. below the process temperature, and this heat abstraction is performed quickly by shutting off the combustion gas to the heating tubes, allowing the combustion air to cool the tubes. During this portion of the cycle the methane flow is reduced to 5 c.f.h. and the ammonia flow increased to 15 c.f.h.

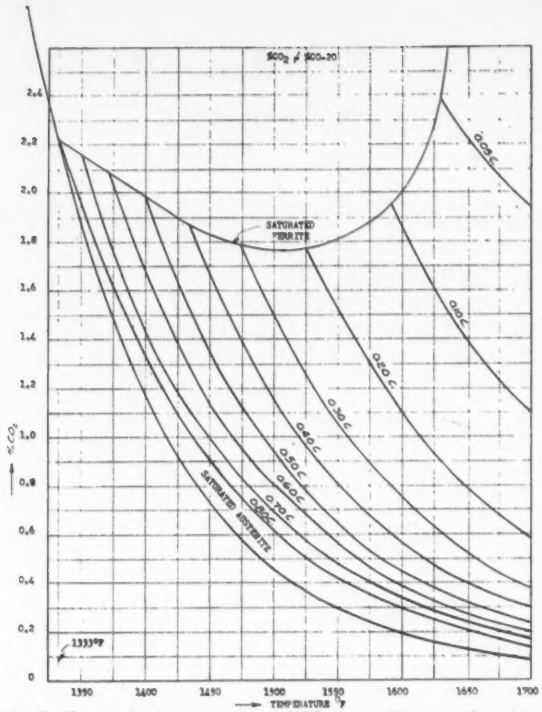


Fig. 9—Curves showing percentage of CO_2 in equilibrium with various carbon contents at various temperatures.

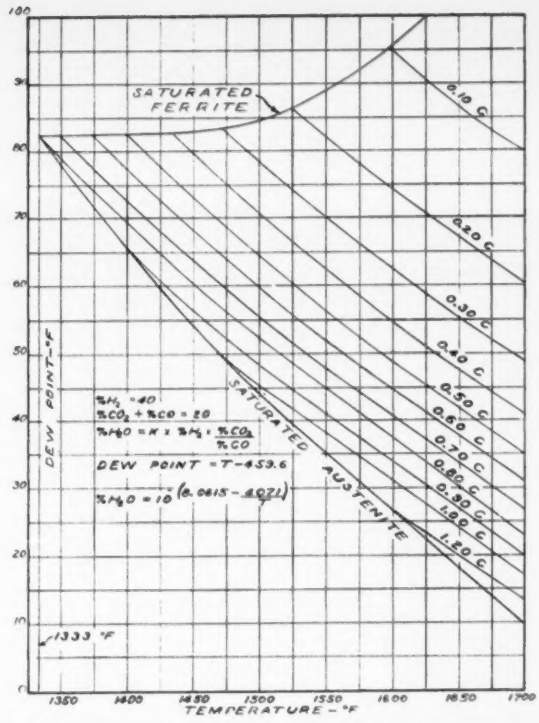


Fig. 10—Curves showing dew points in equilibrium with various carbon contents at various temperatures.

Completing the four-hour cycle, the transfers previously discussed are consummated and we may proceed to the problem of the interrupted or hot oil quench. The potentialities of hot oil quenching depend to a great extent on the proper handling or control of the atmosphere throughout the cycle. Quenching rates are quite sensitive to the surface condition of the parts as quenched and a clean, stain-free surface is particularly desirable. For the hot chamber, control of the natural gas additive will avoid carbon throw down or sooting of the work. In the vestibule, the atmosphere must be non-oxidizing, for here the film formation rate on the hot stock as it is transferred to the bath can be very rapid. A continuous protection of the bath from air is necessary to avoid surface films and deposits during the quenching operation itself.

Other precautions are mandatory for continued success in quenching with hot oil. The composition of the mar-quench oil as supplied affects film formation to a great degree. The manner in which the oil is heated and recirculated may well control the breakdown or thickening of the oil, and the relationship of the bath volume to the size of the quenched load must be carefully considered in controlling sludging.

Let us return to the operating conditions for our shaft load in the quench. The oil has been continuously recirculated at a moderate rate past gas fired tube coils with large transfer surfaces to assure a uniform temperature of 325°F. throughout the bath. As the lowerator descends, the propeller speed automatically changes to a predetermined higher value—a vari-speed drive is provided—and this rate of circulation is maintained through the quench period. The directional control of the oil flow depends to a great extent on our initial loading as well as on the positioning of the lowered container in relation to the baffling and location of the propeller.

With proper protection of the oil, and with control of the loading, oil velocity and oil temperature variables, much can be done to extend the practice of hot oil quenching to the advantage of metallurgical processing.

Perhaps no one point in atmosphere processing deserves more attention than the maintenance of proper carbon potentials of the carrier gas composition as it is found in the heating chamber. The atmosphere composition with its relationship to carbon content and temperature is shown in terms of per cent CO_2 in Fig. 9, and in terms of dew point in Fig. 10. These curves apply to carrier gases made from air-CH_4 mixtures, and must be adjusted if the dilution factor is excessive, due to an indiscriminate use of additives. While the potential of a carrier gas may be readily lowered by adding air to the hot chamber, the reverse practice of increasing the carbon potential of the carrier gas by adding methane is not advisable. The high heat chamber of itself is not the proper vehicle for the carrier gas reaction since methane additions to the hot chamber for increasing the carbon potential require amounts many times greater than those indicated by the carrier gas reaction as performed in the presence of a catalyst. *(Continued on page 30)*

WATCH THAT LAST STEP!

(Quenching is the pay-off in Heat Treating)

Every step may be perfect—steel analysis, temperatures, atmospheres — but it's the *quench*, the last step in the heat treating process that makes the rest of the operation pay off.

When the quench is oil, don't take chances —use Houghto-Quench. This finest of quenching oils provides complete "wetting" of the part—no soft spots, less carry-off. No light ends to distill off under heat . . . remains stable and unchanged for years. It gives you faster quenching than any other oil . . . and this speed assures adequate hardness even for heavy sections and for steels in the low hardenability range.

Ask the Houghton Man to show you how Houghto-Quench increases heat treating effectiveness. Write for the latest "Quenching Handbook" to E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

HOUGHTO-QUENCH OILS . . . products of

E. F. HOUGHTON & CO.

PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

X-RAYS AND HEAT TREATING

By **ROY W. DRIER**

Professor, Dept. of Metallurgical Engineering,
Michigan College of Mining & Technology,
Houghton, Michigan

FROM the time prehistoric man first used native metals in preference to stone, man has been interested in the physical properties of metals and has been continuously attempting to make these properties subject to his will. Control of physicals, really the tailor-making of alloys, is basic to much of modern metallurgical research. Heat treating is exceedingly important in the control of properties of metals and alloys.

Physical properties of metals and alloys are in great part due to the arrangement, size and crystallizing characteristics of the atoms involved. These atoms are held in position by forces of attraction and repulsion. At atomic dimensions these forces are not entirely understood, but it is known that movement of the atoms away from their stable or equilibrium conditions sets up differential strains within the solid, and these strains greatly affect physical properties.

The introduction of a foreign atom into the lattice of a metal, or alloying, results in one type of disturbance of the solvent atoms from their normal, equilibrium positions. The greater the disparity in size between the solvent atom and the dissolved atom, the greater will be the variation from the normal equilibrium lattice of the solvent and consequently the greater the change in physical properties. These dissolved atoms may have a tendency to solidify in a different crystalline pattern than the solvent lattice, and this leads to a condition of strain. Deformation of a metal changes atom position and if the atoms do not have sufficient energy to return to a position of equilibrium, their condition is one of strain, again affecting the physicals. Polymorphic transformations as well as eutectoid, eutectic and peritectic reactions require rearrangement of the atoms and whether they are permitted to go to completion, that is, to equilibrium, or not, affects physical properties. Precipitation from solid solutions, whether incipient (preperceptible) or ranging to completion, involves change in atomic position.

All atomic movement whether away from equilibrium positions or towards them results in a change in the physical properties of the metal involved, and by controlling the movements of the atoms, with respect to their equilibrium arrangement, we are able to control physical properties.

Microscopy and crystallography have been of great aid in helping crystallographers to surmise the arrangement of atoms in matter, but it was not until the advent of x-ray diffraction that we were able to definitely determine the spacial distribution of atoms. By means of diffractometry we are able to determine not only positions of atoms, but also whether they are in equilibrium positions with balanced stresses, or whether the stresses are in a metastable condition. We can tell whether the slip planes are plane or roughened and we can determine grain size below the microscopic range.

Heat treatment includes the entire gamut from a dead or complete anneal whereby the atoms go to equilibrium condition, to the other extreme where maximum physical properties accompany maximum strain. It is the province of the heat treater to so control the movement and positions of the atoms that the desired properties are obtained.

Annealing results in complete removal of strain. Optimum annealing temperature and time of annealing are most admirably obtained and controlled by x-ray diffraction. Small amounts of impurities have much effect on heat-treating temperatures and the amount of time at temperature. Diffractometry is a most excellent analyzer of such heat treating factors. X-rays have explained why it is not always possible to get the same heat treating effect with a long exposure as with a short time at a high temperature, as was previously thought to be the case.

Metals which have been cold worked such as wires, sheets and foils which have become fibered have a strongly preferred orientation of their unit cells (and thus the atoms in the cells). These orientations confer directional properties on the material which are sometimes desirable, and not desirable at others. Forming steel, for example, should have no such directional properties. Heat treating removes directional properties and x-rays are excellent indicators of the removal.

Heat treatment of cold rolled foils can have one of three results. The foil can be completely annealed, removing all the preferred orientation of the fiber

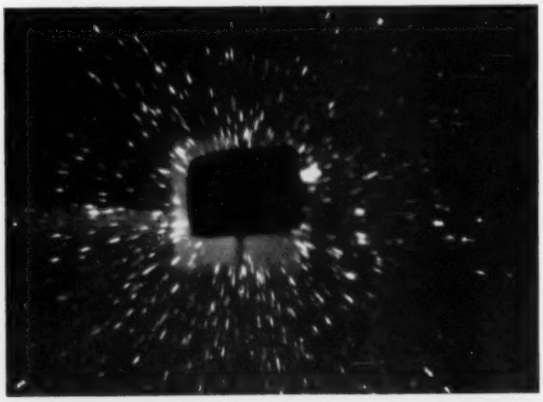
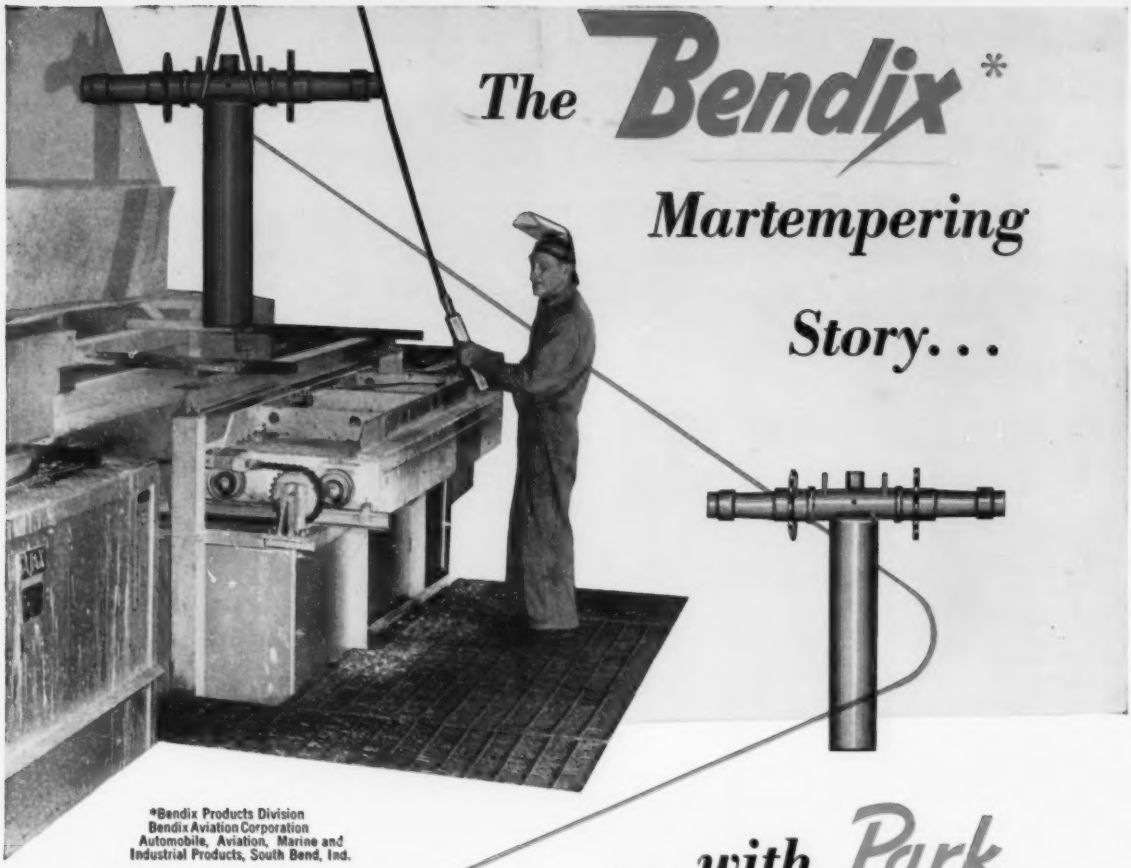


Fig. 1—Annealed copper amenable to cold working.



The Bendix* Martempering Story...

*Bendix Products Division
Bendix Aviation Corporation
Automobile, Aviation, Marine and
Industrial Products, South Bend, Ind.

PART

Products are aircraft landing gear steel components, including forgings, arc and flash welded assemblies, basically tubular with complex lugs.

PROBLEMS

1. Eliminate decarburization and scaling.
2. Reduce distortion.
3. Reduce residual stresses resulting from heat treatments.

SOLUTION

Using an immersed electrode-type furnace 96" deep, these complex parts were austenitized in Park Chemical's Nu-Sal neutral salt at 1550°F. for 45 minutes. Previous method used 1½ hours. Quench at 400°F. is in Park Chemical's Thermo Quench Salt. Steels used are AMS 6324, AMS 6415 and AMS 6427.

Salt baths offer tremendous advantages over conventional heat treating methods. As much as 80% of all heat treating can be done in salt. Speedy handling and small floor space cuts costs. Quality is increased by eliminating quench cracks, scaling and decarb, while improving toughness and ductility.

Sixth in a series of advertisements describing Park processes on the job

...with Park

NU-SAL NEUTRAL SALT

(Melting point 1230°F. / working range 1300-1650°F.)

and

THERMO-QUENCH SALT

(Melting point 290°F. / working range 325-1100°F.)

• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement

Park

PARK CHEMICAL CO.

8074 Military Avenue • Detroit 4, Michigan

Send Free Bulletin on Neutral Salt Baths

Name_____ Position_____

Company_____

Address_____

City_____ State_____

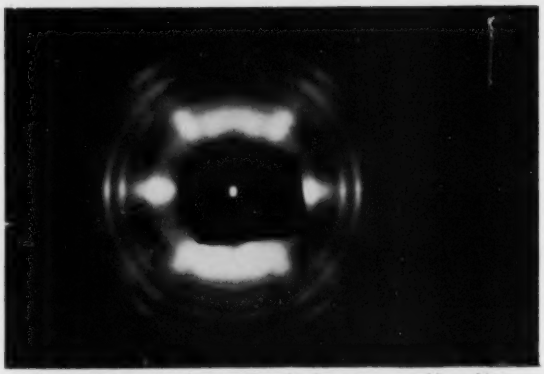


Fig. 2—Copper foil (strained) unfit for extreme cold working.

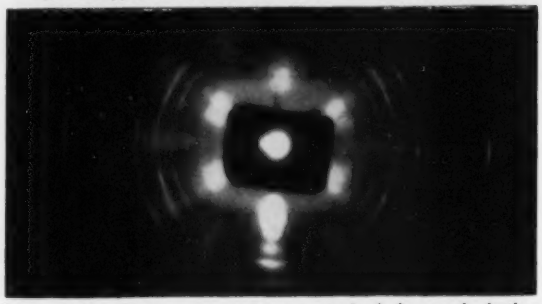


Fig. 3—Cold drawn copper wire too strained for much further reduction.

structure resulting in the recrystallization of uniaxed randomly oriented grains. The heat treatment can also result in a new preferred orientation which eventually changes to the annealed random condition at temperatures near the melting point. Or the result of the heat treatment can be a different preferred orientation that persists right up to the melting point. These conditions all have different physical properties and can only be indicated by diffractometry.

Heat treatment relieves strains caused by rapid chilling of castings. Again diffractometry, the x-ray method, is a most powerful tool in determining how completely the internal strains have been removed.

Modern x-ray equipment and techniques offer a most effective method of attack on such problems as center around the presence or absence of one or more phases; or any allotropic transformation phenomena; such as the detection of residual austenite. Similarly, x-ray spectrometry is ideally suited for rapid chemical analysis, particularly for the detection of extremely minute amounts of microconstituents which more and more are becoming known to play an important part in phase transformation and atomic movement (heat treating) and in resulting metal properties.

And so the x-ray, that universal tool that not only has been the means of man's knowledge of the structure of the atom and of gas cavities in castings, is now used to enable the heat treater to watch the change of modes of atomic arrangement in matter and to freeze or perpetuate any arrangement or partial change of arrangement to best suit the material to the user's needs. ■■■

ABSTRACTS

Flame Hardened Ductile Irons

(Materials and Methods, November, 1955)

The wear resistance of ring gears in a paper mill drive, of iron rolls for cold rolling titanium, of crane wheels, and of sprockets—just to mention a few examples—has been greatly improved by using ductile irons which have been flame hardened.

Data gained from experience in the flame hardening of ductile iron indicate that the material responds well and has excellent wear resistance, compared with surface hardened cast iron or steel. The technique is similar to that used with alloy steel of medium hardenability.

Various investigations have shown that the hardening response to induction heating of ductile iron is dependent upon rate of heating, time and temperature above the critical, and prior structure. A fully pearlitic structure will harden more readily than one that is largely ferritic. A partially pearlitic structure responds adequately to hardening to a satisfactory hardness level of about RC 55. Fully ferritic iron responds less readily and requires either holding for longer times at temperature or increasing the austenitizing temperature.

Heating temperature and time, influencing the amount of dissolved carbon, section size and rate of quench, are influential factors and determine the final hardness value.

Care should be taken that all, or substantially all, of the internal stresses are removed from the castings prior to flame hardening. If the castings are in the as-cast condition and are predominantly pearlitic, they should be given a fairly high temperature stress relief for a relatively short time, as, for example, tempering at 1100-1200°F. for 1 hr. per in. of casting section. If this is not done in a design where the casting sections are under restraint, cracks may develop under the hardened case.

Following flame hardening, if quenching behind the flame has been used, the castings should be transferred, before cooling to room temperature, to a low temperature, stress relieve at 300-400°F. for an hour or more, and then cooled in air. This serves to reduce the high interface stresses between the hardened zone and the base metal to a harmless level without appreciable reduction in the hardness of the case. It is not necessary to apply this stress relief to material hardened by the self quench method.

In the shop, responsible personnel should know the approximate micro-structure of the iron in order to choose the proper hardening technique. If the pearlite content is high, the self quench method is generally adequate to achieve a satisfactory level of hardness and is the preferred one to minimize stresses developed during hardening. ■ ■ ■

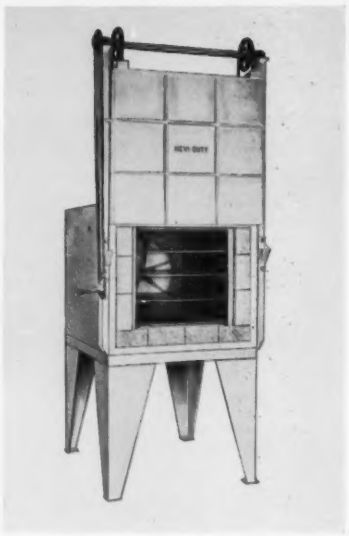
NEWS TO HEAT TREATERS...

CONVECTION FURNACE

A new line of Temperite Convection Furnaces with a temperature range to 1350°F. has been announced by Hevi Duty Electric Company, Milwaukee, Wis.

These furnaces are designed to assure temperature uniformity in all parts of the work chamber. Forced circulation by a high speed fan and a special alloy baffle which directs the flow of air, assures positive circulation. The heat is transferred rapidly and uniformly from the heating elements to the work. The sturdily constructed furnace shell is insulated with preformed layers of graded insulation to reduce radiation loss.

Low cost economical operation is achieved because the electric heating units are placed on the sides of the work chamber. No heat is lost up a flue or from the circulation of hot gases outside the furnace chamber. The long life



heating elements are of the highest grade coiled nickel-chromium wire held in ceramic refractories.

This Hevi Duty Temperite Convection Furnace is available in nine standard sizes.

For further information circle No. 1

VERTICAL PIT-TYPE FURNACE

Prior to a finish machining operation at the Westinghouse atomic equipment department plant in Cheswick, Pa., the rotor of the electric motor in a canned motor-pump, is given a heat treatment in a vertical, 15-foot deep furnace. This pit-type furnace is manufactured by the Westinghouse Industrial Heating Division at Meadville, Pa. The rotor will be heated to a temperature of 1350°F for 10 hours, and then allowed to cool under controlled conditions. The

heat treating process relieves any conditions of stress that might have been set up during the various manufacturing operations.

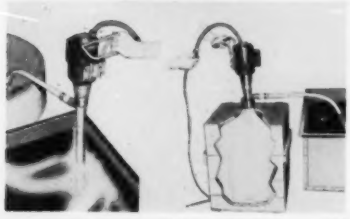
For further information circle No. 2

NEW STRIP MILL

Crucible Steel Company of America has announced plans for installation of a new $2,500,000 mill for cold rolling stainless and titanium strip to thinner gauges than the company has previously produced. The mill, a 50" Sendzimir reversing cluster mill, will be the largest of its kind ever built for this purpose. It will be installed at Crucible's Midland, Pa., Works and will be in addition to already existing stainless and titanium cold rolling facilities. Installation is scheduled for completion in 1957, with a probable increase in work force at that time.

The flexibility of the mill will permit production of small or large quantities of particular grades of stainless and titanium to meet exacting market demands for gauge and surface finish.

PORTABLE ELECTRIC ACID PUMP



A new portable electric acid pump which conveniently and safely transfers acids from open vessels as well as from standard carboys and drums has been announced by the General Scientific Equipment Company, Philadelphia. All previous pumps of this type were limited to use on closed vessels.

The Centri-F Pump is particularly useful in transferring acids from plating, pickling or small storage tanks. It is completely self-draining. No acid remains in the pump when it is removed from the container, thereby providing absolute operator safety.

Driven by a specially designed, entirely enclosed electric motor, the Centri-F Pump delivers a steady, spurt-free flow of acid at the rate of approximately six gallons a minute. Self-priming and light-weight, the pump is easily positioned and operated by one man. Pump is furnished in materials suitable for the particular acid service specified.

For further information circle No. 3

MICROMETER TESTING INSTRUMENT

An operator checks his micrometer against the one inch cylinder of a new master gage set of unusual pyramid design. Named the Mikemaster by the manufacturer, Size Control Company, Chicago, the instrument consists of six lapped, hardened, and normalized tool steel cylinders, graduated from one

inch to six inches, and calibrated to four decimal places. Since the cylinders are permanently attached to a wooden base there is less handling of the fine masters.

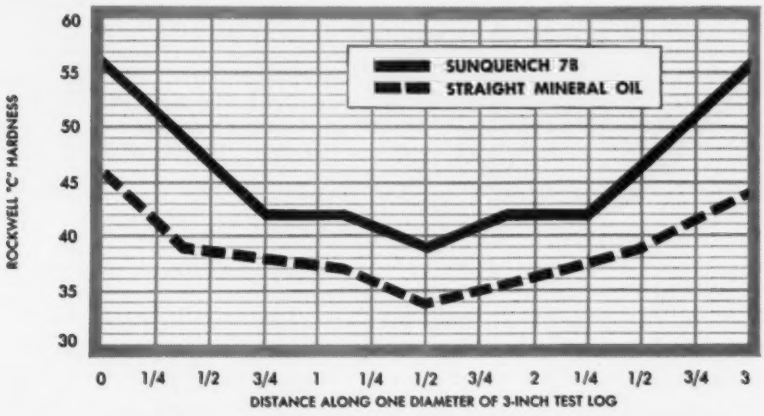
For further information circle No. 4

CERAMIC FIBER ROPE

Fiberfrax rope, a new form of The Carborundum Company's heat resistant Fiberfrax ceramic fiber, is easily installed into an expansion joint. Made of long staple, the rope has good resiliency, a feature which, along with its light weight, gives it handling and installation advantages in many high temperature applications. The new Fiberfrax


NEW! FAST! LONG LASTING!...
A new high-speed quenching oil
with an extra-long service life

....SUNQUENCH 78



Three-inch test logs of AISI 4140 were quenched in both SUNQUENCH 78 and a conventional quenching oil. The graph shows the results.

SUNQUENCH 78* was developed for those tough quenching jobs where a conventional quenching oil can't give you satisfactory results. For example:

Easily distorted parts can be satisfactorily quenched in SUNQUENCH 78. It rapidly wets out all surfaces and produces a uniform quenching action.

Baskets of tightly packed parts can be quenched more uniformly because of the efficient cooling action of SUNQUENCH 78.

Baths with inadequate agitation frequently can't develop full hardness with conventional quenching oils. Here again, SUNQUENCH 78 is the answer.

Steels of low hardenability, which have been substituted for more expensive alloy steels, develop maximum hardness and strength when they are quenched in SUNQUENCH 78.

The long service life of SUNQUENCH 78 is just as important as its high-speed quenching action. Special inhibitors give SUNQUENCH 78 an exceptionally high thermal and oxidation stability. Even at abnormally high quenching-bath temperatures, SUNQUENCH 78 has very little tendency to thicken-up or form cooler-clogging sludge.

For more information on new SUNQUENCH 78, and other Sun Quenching Oils, see your Sun representative or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MR-5.

SUNOCO®

*TRADE-MARK

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY PHILADELPHIA 3, PA.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO AND MONTREAL

rope keeps its form and properties under temperatures as high as 2300°F.

For further information circle No. 5

PLANT MERGER

The Lindberg Industrial Corporation at 2321 West Hubbard Street, Chicago, has purchased the good will, drawings and other assets of the Jet Combustion Company of Chicago, according to L. H. Remiker, President of Lindberg Industrial Corp.

The Lindberg Corporation designs and builds large industrial furnaces for melting and heat treating metals and for firing ceramics. Jet Combustion Company, organized in 1941 by the late J. E. Tegarden has specialized in rotary forge furnaces and other large steel mill heating equipment.

Operations of both companies will be merged at the Lindberg plant at the above address.

NEW 'SURFACE' AD MANAGER

Hans W. Bluethe has been promoted to Advertising Manager, Industrial Division, of Surface Combustion Corporation, Toledo, Ohio.

Mr. Bluethe joined the company's industrial Advertising Department in May 1955. Prior to his coming to Toledo he had been promoting industrial heating and control equipment for such companies as Lindberg Engineering Company, Wheelco Instruments Company and an industrial advertising agency in Chicago.

PROTECTIVE SKIN CREAM

Solucone, a new, heavy-duty, protective skin cream, developed specifically for industrial use, has been introduced by Soluol Laboratories Inc., of Natick, Rhode Island. It contains Silicone (dimenthylpolysiloxane) as the protective agent, in an effective vanishing base. When applied, it maintains a silicone protective barrier that pre-

(Continued on page 43)

SALT BATH HEAT TREATING

Cuts Production Costs!

TYPICAL!

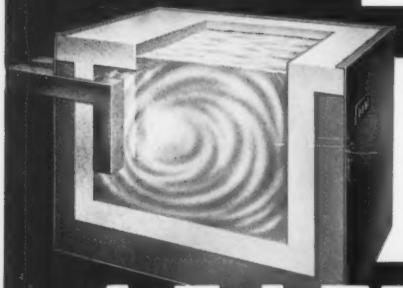
Rejects due to distortion were cut 85% by hardening this clutch lever in Ajax salt baths. Uniform hardness was easily obtained.

1 Parts don't warp out of shape

Distortion of parts is *always* materially less in salt baths than in any other heat treating method because of "automatic preheat," uniform conduction heating of all surfaces regardless of size, ease of fixturing, and the natural buoyancy of molten salt. Most grinding can be completed *before* parts are hardened.

2 Parts get complete surface protection

No atmosphere problems exist since all air is "sealed out" by the molten salt. Even when transferred from one bath to another, a film of molten salt clings to parts, protects them fully to the instant of quenching. Scale and decarb are avoided.



3 Parts heated uniformly throughout

Internal heating by closely-spaced electrodes creates an automatic, electrodynamic stirring action that keeps heat uniform in *all parts of the bath*. Heat treating results are remarkably consistent.

AJAX

HULTGREN

electric SALT BATH furnaces

Cost-savers for

. . . practically any heat treatment
. . . practically any alloy.

ASSOCIATE COMPANIES:

Ajax Electrothermic Corp., Trenton, N. J.
—High-frequency induction furnaces

Ajax Electric Furnace Corp., Phila., Pa. / Low-frequency
Ajax Engineering Corp., Trenton, N. J. \ induction furnaces

25th YEAR

MAIL COUPON FOR CASE HISTORY BULLETINS

AJAX ELECTRIC COMPANY,
940 Frankford Ave. Philadelphia 23, Pa.

Send actual Case History Data on applications checked:

- ☐ Austempering-Martempering
- ☐ Annealing
- ☐ Brazing
- ☐ Carburizing, Cyaniding
- ☐ Hardening
- ☐ Cleaning, Descaling, etc.

Other ☐ _____

☐ Check here for free HEATING TIME CALCULATOR for salt baths.

Name _____ Position _____

Firm _____

Address _____

INSTITUTE NEWS

New Orleans Spring Meeting

The 1956 Spring Meeting of the Metal Treating Institute was held April 30, May 1 and 2 at the Hotel Roosevelt in New Orleans, La. The attendance was excellent with more than three-quarters of the membership together with their wives, children and guests being present.

The program began with a "Get-together Breakfast" on Monday morning. This was followed by a technical and business session at which Mr. W. D. Manly, Associate Director, Metallurgy Division, of the Oak Ridge National Laboratory presented a well-illustrated lecture on the subject of "Reactor Materials and Reactor Technology." This was followed by the presentation of a progress report of the Affiliate Membership Committee by its chairman, Mr. Fred Heinzelman, Jr. He reported the pros and cons of the question of affiliate or associate membership in the Metal Treating Institute as seen by the various members of the committee and then asked for a discussion by the members in attendance. After an interesting expression of various viewpoints, President Bosworth explained that the committee would continue its studies and give a full report at the Fall Meeting in Cleveland in October.

After lunch, those who wished went on a walking, guided tour through the French Quarter of New Orleans. Others went golfing and swimming at the New Orleans Country Club thanks to the courtesy and efforts of Mr. Harry Davies of New Orleans, a personal friend of Secretary Herington and Past-President A. M. Cox. Mr. Davies also secured guest cards for the famous Petroleum Club.

Monday evening was featured by a private dinner party for the entire group at the famous Antoine's Restaurant. There was dancing in a private room after dinner, and over 95 people attended.

Tuesday's business session began with a 45-minute sound film prepared by the American Management Association and entitled "You Are There at the Bargaining Table." This was followed by a demonstrated lecture that has been described as one of the most interesting and educational presentations that has ever been given at any meeting of the Institute. The lecture was entitled "Have You Tried Listening", and was presented by Prof. W. Wiksell of Louisiana State University.

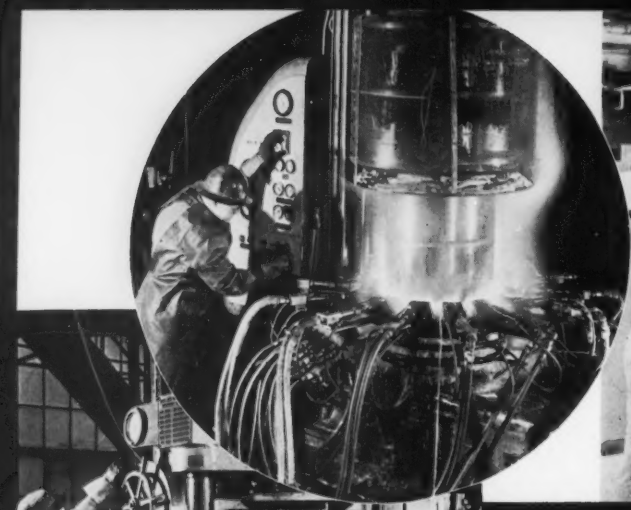
The afternoon was spent by many members and their families on board the river steamer "President" which took them for a three-hour harbor trip. Tuesday evening was left open for unprogrammed fun.

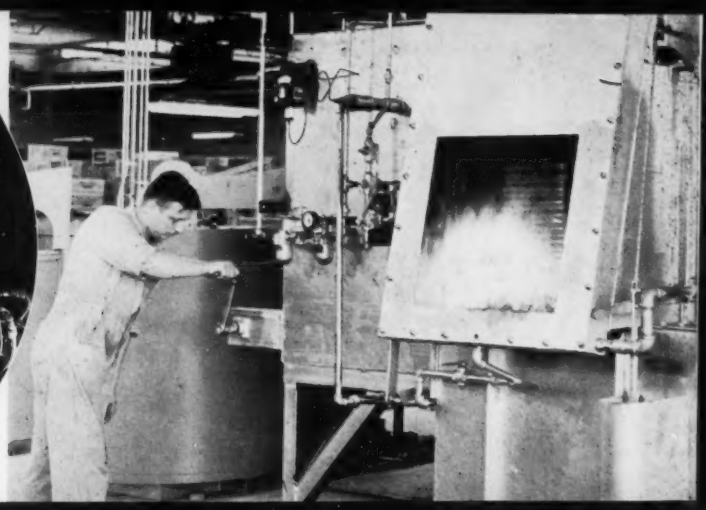
The highlight of Wednesday's session was the panel discussion on the general subject of "What's Your Problem." Members in the audience submitted questions on heat treating problems that involved aspects of production, labor, and management, and various members of the panel gave their answers. The moderator was Mr. C. I. Wesley of Wesley Steel Treating Co., Milwaukee, Wisc., and the panel was composed of the following guests (see cut): "Jackson" Martindell, President of American Institute of Management, New York City; "Jimmy" Sorenson, Chief Metallurgist of Four Wheel Drive Auto Co., Clintonville, Wisc.; "John" Mirzejewski, Special Consultant to Kearney and Trecker Corp., Milwaukee, Wisc.; and "Cliff" Cook, President of Cook Heat Treating Co. of Texas, Houston, Texas and Past-President of the Institute.

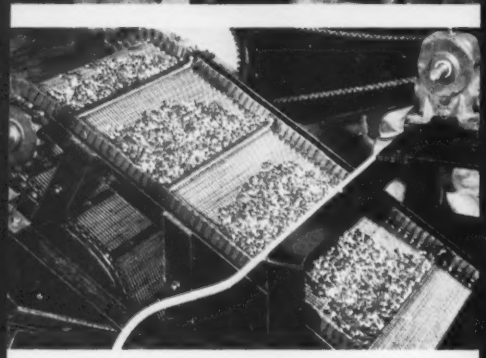
A bus tour in the afternoon followed by the reception and banquet in the evening closed the interesting and entertaining three-day convention.

Publication Committee Additions

The two new names which appear in the masthead on page 1 under the Publication Committee listing—those of Mr. K. U. Jenks of Lindberg Steel Treating Co., Melrose Park, Ill., and Mr. C. R. Weir of Commonwealth Industries, Inc., Detroit, Mich.,—are the result of the recent announcement by President Bosworth of their appointment to the Publication Committee of the Institute.







You need MORE than these to Heat Treat Metals!

The science of heat treating has become of vital importance to many manufacturing operations. Without the radical improvements of the properties and characteristics achieved in metals and alloys by heat treating, many of the nation's most important products could not be made.

To perform the appropriate type of heat treatment, such as annealing, normalizing, quenching, tempering, carburizing, controlled atmosphere hardening, stress relieving and others requires specialized, intricate, and expensive equipment such as is illustrated here.

But *more* than such equipment is needed. The most modern and highly specialized equipment is useless without the correct combination of operational skill and technical experience that has been developed over years of practical operating practice. Equipment and materials are important, but the *essential* factor in heat treating operations of all kinds is the human touch and the practiced hand.

The members of the Metal Treating Institute listed here are the recognized leaders of the commercial heat treating industry. They are specialists possessing the equipment, the technical skill, the years of experience, and the personnel with which to solve your heat treating problems all under one roof.

When you need complete heat treating services or want consultation concerning heat treating or engineering or design problems, write any of the companies listed. All inquiries will receive prompt attention.

WRITE FOR A COPY OF A BOOKLET
"A REVIEW OF SALT BATH CARBURIZING"

MTI
MASTER CRAFTSMEN
METAL TREATING INSTITUTE

METAL TREATING

THERE'S A HEAT TREATING SPECIALIST NEAR YOUR PLANT

ALABAMA

Southern Metal Treating Co., Inc.
3131 10th Ave., North, Birmingham 4

CALIFORNIA

Hollywood Heat Treating Co.
6902 Santa Monica Blvd., Los Angeles 38
Lindberg Steel Treating Co.
2910 S. Sunol Drive, Los Angeles 23
Malloy Heat Treating Co.
11648 So. Atlantic, Lynwood
Cook Induction Heating Co.
4925 East Slauson Ave., Maywood
Industrial Steel Treating Co.
1549—32nd St., Oakland 8

COLORADO

Metal Treating & Research Co.
4110 Fox St., Denver 16

CONNECTICUT

Commercial Metal Treating, Inc.
89 Island Brook Ave., Bridgeport 6
Stanley P. Rockwell Co.
296 Homestead Ave., Hartford 12

ILLINOIS

Senecca Heat Treating Co.
124 S. Batavia Ave., Batavia
Accurate Steel Treating Co.
2226 W. Hubbard St., Chicago 12
Dura-Hard Steel Treating Co.
2333 West Deming Place, Chicago 47
Pearson Industrial Steel Treating Co.
5757 W. Ogden Ave., Chicago 50
Perfection Tool & Metal Heat Treating Co.
1756 West Hubbard St., Chicago 22
Fred A. Snow Co.
1942 West Kinzie St., Chicago 22
American Steel Treating Co.
P. O. Box 225, Crystal Lake
Eklund Metal Treating, Inc.
721 Beacon St., Loves Park
Lindberg Steel Treating Co.
1975 No. Ruby St., Melrose Park
O. T. Muehlemeyer Heat Treating Co.
1531 Preston St., Rockford
C. U. Scott & Son, Inc.
1510 First Ave., Rock Island

MARYLAND

Maryland Tool Company
111-13 Hollingsworth St., Baltimore 2

MASSACHUSETTS

New England Metallurgical Corp.
475 Dorchester Ave., South Boston 27
Porter Forge & Furnace, Inc.
74 Foley St., Somerville 43
Greenman Steel Treating Co.
284 Grove St., Worcester 5

MICHIGAN

Anderson Steel Treating Co.
1337 Maple St., Detroit 7
Bosworth Steel Treating Co.
18174 West Chicago Blvd., Detroit 28
Commercial Steel Treating Corp.
6100 Tireman Ave., Detroit 4
Commonwealth Industries, Inc.
5922 Commonwealth Ave., Detroit 8
Michigan Steel Processing Co.
3120 Denton, Detroit 11
Standard Steel Treating Co.
3468 Lovett Avenue, Detroit 10
Vincent Steel Process Co.
2424 Bellevue Ave., Detroit 7
State Heat Treat, Inc.
520 32nd Street, S. E., Grand Rapids 8
American Metal Processing Co.
12000 East Nine Mile Road, Van Dyke

MINNESOTA

Metallurgical, Inc.
900 East Hennepin, Minneapolis 14

MISSOURI

Metallurgical, Inc.
1727 Manchester Ave., Kansas City 8
Lindberg Steel Treating Co.
650 East Taylor Ave., St. Louis 15
Paulo Products Co.
5711 West Park Ave., St. Louis 10

NEW JERSEY

Ace Metal Treating Corp.
611 Grove St., Elizabeth
American Metal Treatment Co.
Highway 25 and LaFayette St., Elizabeth
Benedict-Miller, Inc.
Marin Ave. and Orient Way, Lyndhurst
Bennett Heat Treating Co., Inc.
246 Raymond Boulevard, Newark 5
L-R Heat Treating Co.
107 Vesey St., Newark 5
Temperature Processing Co., Inc.
228 River Road, North Arlington
Metro Heat Treat Corp.
9 Victoria Terrace, Ridgefield

NEW YORK

Fred Heinzelman & Sons
138 Spring St., New York 12
Alfred Heller Heat Treating Co., Inc.
391 Pearl St., New York 38
Metro Heat Treat Corp.
466 Broome St., New York 13
Lindberg Steel Treating Co.
620 Buffalo Road, Rochester 11
Rochester Steel Treating Works
962 Main Street, E., Rochester 5
Syracuse Heat Treating Corp.
1223 Burnet Ave., Syracuse 3

OHIO

Queen City Steel Treating Co.
2980 Spring Grove Ave., Cincinnati 25
Ferrotherm Co.
1861 E. 65th St., Cleveland 3
Lakeside Steel Improvement Co.
5418 Lakeside Ave., Cleveland 14
George H. Porter Steel Treating Co.
1273 East 55th Street, Cleveland 3
Reliable Metallurgical Service, Inc.
3827 Lakeside Ave., Cleveland 14
Winton Heat Treating Co.
20003 West Lake Road, Cleveland 16
Dayton Forging & Heat Treating Co.
2323 East First St., Dayton 3
Ohio Heat Treating Co.
1100 East Third St., Dayton 2

PENNSYLVANIA

Robert Wooler
Limekiln Pike, Dresher
J. W. Rex Co.
834 West 3rd St., Lansdale
Drever Company
220 West Cambria St., Philadelphia 33
Lorenz & Son
1351 N. Front St., Philadelphia 22
Metlab Company
1000 East Mermaid Lane, Philadelphia 18
Wiedemann Machine Co.
4272 Wissahickon Ave., Philadelphia 32
Pittsburgh Commercial Heat Treating Co.
49th St. and A.V.R.R., Pittsburgh 1

TEXAS

Dominy Heat Treating Corp.
P. O. Box 5054, Dallas
Superior Heat Treating Co., Inc.
P. O. Box 1686, Fort Worth 1
Cook Heat Treating Co., of Texas
6233 Navigation Boulevard, Houston 11
Lone Star Heat Treating Corp.
5212 Clinton Dr., Houston 20

WISCONSIN

Allied Metal Treating Corp.
830 S. Fifth St., P. O. Box 612, Milwaukee 1
Hushek Metal Processing Co.
1536-40 West Pierce Street, Milwaukee 4
Metal Treating, Inc.
720 South 16th St., Milwaukee 4
Supreme Metal Treating Co.
4440 West Mitchell St., Milwaukee 14
Thurner Heat Treating Co.
809 West National Ave., Milwaukee 4
Wesley Steel Treating Co.
1301-1403 West Pierce St., Milwaukee
Harris Metals Treating Co.
4100 Douglas Ave., Racine

CANADA

B. & W. Precision Heat Treating Co.
70 Borden Ave., S., Kitchener, Ontario

INSTITUTE **271 NORTH AVENUE, NEW ROCHELLE, NEW YORK**

THE APPRENTICE CORNER

Editor's Note: *This is a continuation of the article which appeared in the March-April issue.*

SOME QUESTIONS AND ANSWERS ABOUT DECARBURIZATION

By G. E. BRUMBACH, *Metallurgist*

The Carpenter Steel Company, Reading, Pennsylvania

Q. HOW MUCH SURFACE SHOULD BE REMOVED FROM HOT ROLLED, COLD DRAWN OR FORGED BARS TO ELIMINATE DECARB?

A. For all practical purposes, the following machining allowances represent a safe practice to follow:

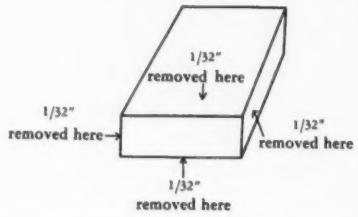
Dimension of Bar	*Minimum Amount To Be Removed Per Side*
Up to ½"	1/64"
Over ½" to 1¼"	1/32"
Over 1¼" to 3"	1/16"
Over 3" to 5"	1/8"
Over 5"	3/16"

For *rectangular sections* where the *width* is less than 4 times the *thickness* use the above machining allowances. When the width is equal to or greater than 4 times the thickness, double the amount given above for the *thickness* dimension.

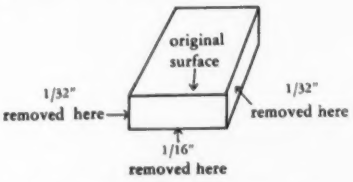
Q. WHAT CAN HAPPEN WHEN DECARB IS NOT REMOVED EQUALLY FROM ALL SIDES OF THE BAR?

A. Some toolmakers do not remove decarb from all sides of the bar . . . particularly from those sides that do not require full hardness. But actually, it's a little like securing your entire house against intruders by bolting only one door. For failure to remove decarb *equally* from *all* sides of the bar is inviting trouble . . . in the form of cracking or excessive warpage in the heat treating of your tools or dies.

To illustrate this point, we made the following test: Two specimens of each of three tool steels measuring 2½" x ½" x 6" were used.



1/32" was machined from each side of three specimens like this.



1/32" machined from each of the two *narrow* sides and 1/16" from only one of the *flat* sides of three specimens like this. The other flat side of each specimen retained the original bar surface.

Both specimens now measured exactly 2-7/16 x 7/16 x 6 inches. Then all test sections were placed on their narrow edges in the furnace and were held in a vertical position during the oil quench.

Table of Distortion Test

Steel	Four Sides Machined
A	0.001/0.0015" out of straight
B	0.001/0.0015" out of straight
C	0.0005/0.001" out of straight

Steel	Only Three Sides Machined
A	0.007/0.008" out of straight
B	0.004/0.005" out of straight
C	0,006/0.007" out of straight

All sections were carefully measured before and after treating and the results given in the Table are differences "out of straight." It is not to be inferred that a tool machined on all sides will not warp, since other factors bear an influence. Unequal heating, position in which the tool is placed in the furnace, the condition of the furnace hearth, the quantity of material in the furnace and the method of quenching—all are factors that influence warping. While being aware of these variables and guarding against them, it is believed that the excessive warpage shown in the second column of the Table was caused entirely by the fact that the original bar surface was not removed from one face of the specimen.

Q. IN VIEW OF THESE CONDITIONS, WHY DO SOME TOOLMAKERS FAIL TO REMOVE DECARB?

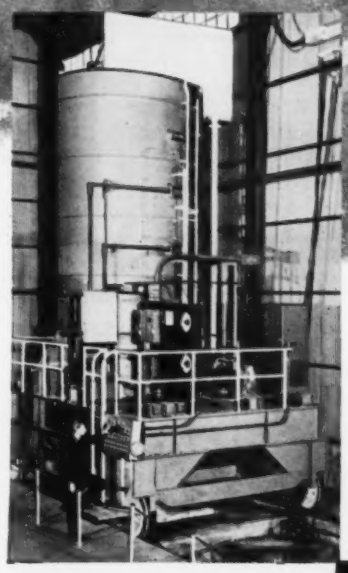
A. Generally, there are two reasons. (1) Occasionally a toolmaker may decide not to remove bar bark, or decarb, in an effort to save machining time. (2) Frequently you may start with a bar of the same size as the finished die . . . therefore no extra surface can be removed. A good rule to follow is to use the next larger bar size available so that the surface of the bar can be properly cleaned up.

Q. CAN DECARBURIZATION ALWAYS BE REMOVED FROM A HARDENED TOOL OR DIE?

A. Unfortunately, it is not always possible. Fig. 5 is a blanking die with such an irregular profile that it is impossible to get into the holes to grind them. Since the *walls* of the holes form one side of the cutting edge, no matter how much is ground off the *top*, the cutting edge will always be low in carbon. This, in turn, will cause a burr on the stamping after a short time in service.

In a case like this, your best bet is to get what production you can from the tool with the decarburized surface, and in the meantime start building a new one from scratch . . . making sure it is completely free of decarb.

Metallurgical, Inc. chooses Armour Ammonia when heat treating jet plane parts!



With the world's largest commercial vertical drop bottom metal treating furnace, METALLURGICAL, INC. of Minneapolis, Minnesota, heat treats parts of extreme length and diameter.

Bright, scale-free steel parts are hardened to critical tolerances under dissociated ammonia atmosphere provided from Armour Ammonia!

Air Force specifications call for extremely close tolerances and the ultimate in structural strength and durability. Metallurgical, Inc. has found that the dryness and extreme purity (99.98%) of Armour Ammonia is a prime factor in obtaining such results.

More and more companies are using Armour Ammonia for modern metal treating techniques, such as nitriding, carbonitriding and the use of dissociated ammonia in the bright annealing of stainless steel and for furnace brazing. They find the use of dissociated ammonia can cut operating expenditures up to 55% because a single cylinder of Armour Ammonia dissociated yields the equivalent of 34 cylinders of hydrogen!

The Armour Technical Service Department will help answer problems arising with ammonia installations for metal treating. Send today for these free booklets. If your problems are unusual or pressing, write giving full details.

Armour Ammonia is available in 116 cities. Save money on our tank truck delivery service!

CLIP AND MAIL TODAY!

Please send me free booklets which I have checked:

- ☐ "Ammonia Cylinder Installations for Metal Treating"
- ☐ "The Role of Water Vapor and Ammonia in Case Hardening Atmospheres"
- ☐ "Case Hardening of Steel by Nitriding"
- ☐ "A Survey of Industrial Carbonitriding Practice"
- ☐ "Investigation into the Carbonitriding of Plain Carbon Steel"
- ☐ "The Carbonitriding of Alloy Steels"
- ☐ Tank truck service information

Name_____ Title_____

Firm_____

Address_____

City_____ Zone____ State_____

TS

ARMOUR *Ammonia Division*

Armour and Company • 1355 West 31st Street • Chicago 9, Ill.

Tool Steel Topics

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Airplane Builder's Change to Bearcat Increases Life of Rivet Sets 5 Times

At the Wichita, Kans., plant of Boeing Airplane Company, rivet sets used on the B-47 and B-52, as well as other types of aircraft, had been providing satisfactory results. But, Boeing engineers reasoned, by checking the performance of other grades of tool steel in the same application, they might discover a tool steel that could do a better, more economical job.

So they ordered Bearcat, from Ford Steel Company, their Bethlehem tool-steel distributor in St. Louis. The results were impressive. The Bearcat sets gave five times longer service life then the sets previously used. In addition, the heads also drove down better, thus minimizing time lost in reworking, and facilitating ready acceptance by Boeing inspectors. Besides, with Bearcat's superior finish, there was less surface pick-up.

Bearcat is our super-tough, air-hardening general-purpose grade. It has exceptional resistance both to shock and to wear. Its air-hardening characteristic minimizes quenching hazards, and provides excellent resistance to distortion in heat-treatment.

In addition to rivet-set applications, Bearcat can be used advantageously for punches, chisels, hot headers, gripper dies and master hobs, as well as for dies used in blanking and bending, and cold-forming.

If you'd like to know more about Bearcat, or perhaps try it out in your shop, just get in touch with the nearest Bethlehem tool-steel distributor.

BETHLEHEM TOOL STEEL ENGINEER ASKS:

How Hard Should Tools Be?

It is sometimes difficult to determine the best hardness for certain tools. As all tools are subjected to wear it is ordinarily desirable to use the highest possible hardness. With most tools, this causes brittleness or breakage, making some compromise necessary. Generally speaking, tool hardness should be lowered from the maximum to a degree which causes the tools to consistently wear out in service, rather than fracture. The optimum hardness for a given type of tool often varies considerably, depending upon the operating conditions. However, here are the average hardnesses of commonly used tools:

TOOL	HARDNESS ROCKWELL C
High-speed steel, metal-cutting tools, single point	65
High-speed steel, metal-cutting tools, multiple point	63
Blanking dies	60
Forming dies	60
Drawing dies, hardened all over	60
Drawing dies, bore-hardened only	66
Gages	60
Shock-resisting tools (punches, etc.)	58
Hot-work tools	40/50
Cold shear blades	60
Hot shear blades	48
Tools subjected to max tensile loads (cylinders, containers, etc.)	53
Tools subjected to max compressive loads (plungers, punches, etc.)	60/65

These hardness figures should be used as a guide only, because for individual jobs the required hardness may be slightly higher or lower, depending upon circumstances.

Tool Steel Color Film An Award Winner

"Teamwork," Bethlehem's 16-mm color film on tool steel, received an award for excellence in the sales promotion field at the recent Columbus Film Festival, held at Columbus, Ohio. The film, being received enthusiastically in all parts of the country, shows the manufacture of Bethlehem tool steels, and explains the reasons behind their quality control and heat-treatment. Typical applications of various grades are included.

The picture runs for 30 minutes. It is available for showings to machinists, diemakers, heat-treaters, machine-tool manufacturers and distributors. Its subject matter makes it excellent for technical society meetings, and for showings to engineering-student groups.

If you would like to see "Teamwork," drop a line to Publications Department, Room 1001, Bethlehem Steel Company, Bethlehem, Pa. If possible, please select a showing date well in advance, to permit adequate time for scheduling and shipping.

Q. CAN DECARB BE PREVENTED IN HEAT TREATING TOOLS OR DIES?

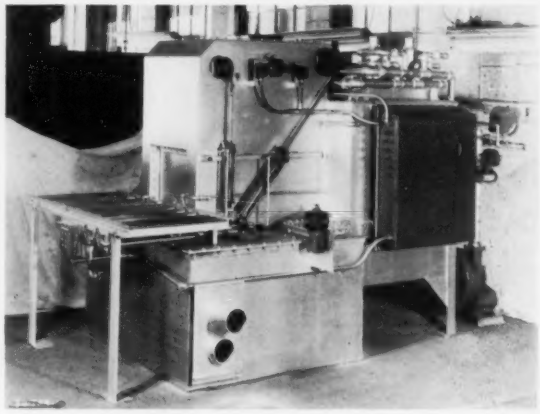
A. Definitely yes . . . through correct atmospheres freely circulating through the furnace, or through the use of salt baths kept up to proper strength, or other types of heating equipment kept in good working order. Check your heat treating equipment regularly to be sure it is in proper condition.

Q. WHAT HAPPENS, IF IN HARDENING, THE PROCEDURE REVERSES ITSELF AND THE TOOL TAKES ON A CARBURIZED SKIN?

A. This condition can also cause trouble. It can be brought about by improper furnace atmospheres or the effects of retained carburizing compounds used on previous carburizing jobs. This can result in the same dangers of cracking and excessive warpage as caused by *de*carburization. It also can result in a tool extremely sensitive to grind . . . causing grinding cracks. Further, the cutting edge of a tool that has a carburized surface tends to be more brittle and is subject to chipping and spalling. (To be concluded in the next issue.)

CONTROLLED ATMOSPHERE EQUIPMENT

(Continued from page 10)



A Smaller Batch Type Unit

For smaller volume operations, the Dow Model HA-400, (Fig. 11), has also been gaining considerable acceptance by both commercial heat treaters and manufacturing plants. This furnace is built along the same general lines as the J-800, illustrated in Fig. 7, and like it, features the "Sealed-Cycle" method of operation. There are two principal advantages to this method, one concerning the quality of the heat treated work, and the other affecting the cost of operation.

The "Sealed-Cycle" principle makes possible the complete cycling of the furnace including quenching, reloading and unloading without exposing the furnace chamber itself to air at any time.

In conventional furnaces where both doors are opened for loading, some contamination and deconditioning is inevitable as the atmosphere burns and the furnace fills with air. This contamination must be corrected by the purging effect of the inflowing carrier gas before the load approaches a hardening temperature and will usually dictate a greater than normal flow of the hydrocarbon additive. The control of the atmosphere composition is thus made more difficult in that the tendency to form soot on the work is greatly increased.

The "Sealed-Cycle" method also reduces to an absolute minimum any empty furnace time, since the dried green load is charged into the furnace immediately after the lowerator has lowered the finished load into the quench. Thus the furnace is unproductive only for a matter of 20 to 30 seconds during each cycle. In light case work this saving in empty furnace time can allow up to a 20% increase in the number of loads processed per day.

The versatility of this unit is found not only in its use for gas carburizing, carbonitriding, clean hardening and carbon restoration but also for hardening or annealing of tools from temperatures up to 1850°F. The unit can be equipped for normal oil quenching, hot oil quenching, slow atmosphere cooling and atmosphere quenching. ■ ■ ■

"The right quench oil for our work is

SHELL VOLUTA OIL 23"

says Garland Wilcox, Chief Metallurgist
Wallace Barnes Co., Bristol, Conn.

...the story of a profitable change

WALLACE BARNES COMPANY and steel springs have "gone together" for nearly a century. Most of today's output is in SAE 1075 or 1095 steel.

Because the quenching operation is so important to the life of springs, the Wallace Barnes laboratory decided to test its regular quenching oil against some of the newer products, including Shell Voluta Oil 23. This is what they found:

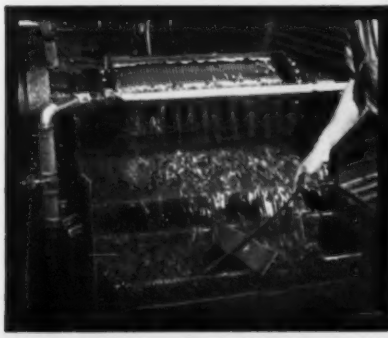
Shell Voluta Oil 23 showed a superior quench rate, with correct hardening and relative freedom from distortion. It drained more rapidly from the quenched parts, reducing dragout loss. It washed off more completely in the alkaline cleaner; it reduced flaming, and cut down on the oil baked to parts.

Wallace Barnes reports that this oil has almost eliminated trouble with "slack-quenched parts," and that heavier stock now goes through without special handling. So . . . Shell Voluta Oil 23 has replaced the former quench oil in all tanks of the spring hardening departments, serving salt pot lines and shaker hearth furnaces.

We'll be glad to provide full information on Shell Voluta Oil 23.

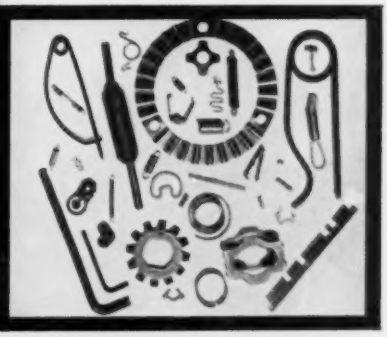
WALLACE BARNES CO.
A division of Associated Spring Corp.
Bristol, Conn.

Photos courtesy "STEEL"



Shaker hearth furnaces automatically dump parts into Shell Voluta Oil 23, then remove and drain them.

Flat springs at austenitizing temperature get a fast quench in Shell Voluta Oil 23.



Over 35,000 prints of production items like these are kept on file at Wallace Barnes Co.

SHELL OIL COMPANY

50 WEST 50TH STREET, NEW YORK 20, NEW YORK
100 BUSH STREET, SAN FRANCISCO 6, CALIFORNIA

SHELL

ISO-HARDNESS

(Continued from page 6)

Most carburizing specifications define surface hardness and the effective case depth (generally measured to 50 Rockwell "C") necessary for a satisfactory part. As a result, the hardness gradient across the carburized case must fulfill at least these two requirements. This establishes two critical areas. The necessary cooling and carbon ranges associated with these critical areas can easily be determined from the Iso-Hardness Diagram. Thus, information necessary to produce the specified hardness can be provided to the furnace operator. His manipulation of the time cycle, temperature, carbon concentration of the carburizing media, and speed of quenching can be performed more efficiently resulting in parts that meet specifications. Varying carburizing conditions are not considered a difficult problem for the trained operator. The problem becomes more difficult if parts of widely different design and mass are to be carburized. However, the steel used should have similar carburizing characteristics in regard to the effect of added carbon upon hardness.

The problem of applying to production practice the technical information presented in the Iso-Hardness Diagram is not as difficult as it might first appear. The hardenability, carbon content, and cooling rates required to produce any hardness within limits are given on the chart. As an example, this procedure may be applied to gear production. First, an analysis of the requirements of the part being carburized is necessary. Basically, the carburized case on gears needs strength to resist three types of failures summarized as follows:

1. Surface failures (hardness required).
2. Pitch line failures (case depth and uniform hardness gradient required).
3. Root line failures (surface hardness and case depth required).

The first point is considered of major importance and the results are not difficult to produce. The carbon associated with the peak is optimum for all quenching rates and carburizing the part to a surface carbon designated by the percentage associated with the peak for the type of steel used is only a problem of control. The allowable range can be met by production practices. Carbon outside of this range at the surface indicates a lack of proper control and the resultant hardness produced may be below specifications. This will lead to early failure under service conditions.

The second point, case depth and uniform hardness gradient, is accomplished by allowing the desired carbon to diffuse to the critical area. In order to establish the amount of carbon required, one must know the production cooling rate in this area. This knowledge can be obtained by two methods. An electronic recorder was successfully used to establish the cooling rates at various positions through the case of a rear axle drive pinion. The production cooling rate can also be obtained by comparison as follows: Select a heat of steel used for the production part and determine its hardenability. Copper plate, pseudo-carburize, and production quench three parts made from this same heat. Determine the hardness traverse across the case area of these samples in the same location as normally used in checking the carburized parts, and average results. By comparing selected hardnesses with the same hardnesses obtained from the end quench test, equivalent cooling rates can be determined. This comparison, if carefully done, will establish the equivalent cooling rate produced by the production quench on the actual part.

Assume the cooling rate at 0.040 of an inch below the pitch line surface of a gear has been determined and is equivalent to an end quench distance of 0.350 inches. What carbon is necessary to produce 50 Rockwell "C" at this location below the surface provided the gear is made from AISI 4028 and a calculated Di of 1.42? Referring to the Iso-Hardness Diagram, Figure 6, the intersection of the 50 R "C" iso-hardness line and the 0.350 end quench distance occurs at 0.52% carbon. This procedure supplies the information needed to control effective case depth as previously defined.

The third point, hardness and case depth at the root line of the gear tooth, is also of major importance due to possible fatigue failures. The above procedure of applying the technical data presented in the Iso-Hardness Diagram can also be used.

In the normal production of a carburized and hardened part, one steel is generally specified. The purchase of this material may be based on chemical analysis or hardenability. Under such conditions, three Iso-Hardness Charts developed from low, medium, and high heats may be utilized for production control work. The critical diameters can be calculated for the individual heats of steel from their chemical analysis. Based on this information, select the chart representing the nearest critical diameter. By interpolation, the percentage carbon required to produce the desired hardness at a predetermined equivalent cooling rate can be determined. This procedure has been applied in processing approximately 500 heats of steel used for rear axle drive pinions. Over 95% of these heats responded to heat treatment as theoretically predicted. Operating costs were decreased and the quality of the part was improved resulting in a reduction of service failures. The adopted procedure was also successfully applied during the critical material shortage in establishing proper heat treating cycles for the substitute steels.

The Iso-Hardness Diagram may be compared to an Iso-Thermal Transformation Diagram. Basically, the latter is a plot which shows the time necessary for the beginning and the ending of austenite transformation at constant temperatures. The Iso-Hardness Diagram is a plot which shows the conditions necessary to produce a constant hardness. However, it not only defines conditions for a constant hardness, but defines the conditions necessary for any hardness. Thus, Iso-Hardness Diagrams may also be applied in selecting and substituting materials since the actual hardenability for all carbon levels can easily be compared.

Iso-Hardness Diagrams are being developed for most of the carburizing grade steels. In addition to AISI 4028, these include AISI 4620, 4720, TS 8117, 4815, 5120, 6120, TS 81B17, TS 8128, 8620 and 94B17. Also, a procedure is being developed for predicting the hardness gradient of a carburized and hardened case utilizing the Iso-Hardness Diagram. Results to date indicated that predicted and actual hardnesses agree within a range of 0 to 2 Rockwell "C" points.

Conclusions

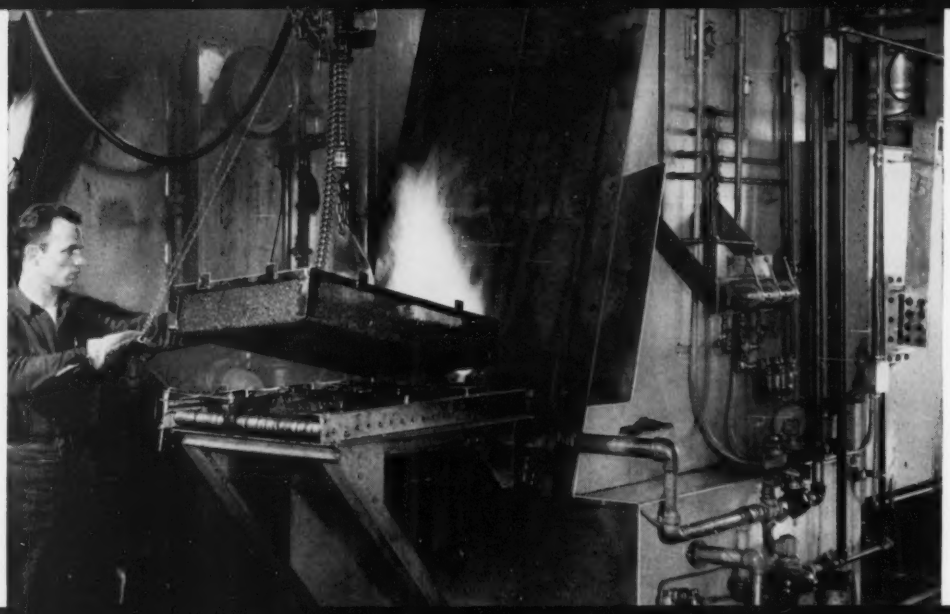
1. A graphic method has been developed clearly evaluating carburized hardenability data and shows the separate and combined effect of cooling rate, carbon, and hardenability on hardness. The peak effect or optimum carbon required to produce maximum hardenability was found to be approximately .85% for AISI 4028 with a calculated ideal critical diameter of 1.42.
2. The Iso-Hardness Diagram is a valuable tool for analyzing steel applications because it describes all factors involved in the hardenability concept. Practical applications to date include controlled carburizing operations, general heat treating, and steel specification. ■ ■ ■

ALLIED

New Lindberg electric furnace with CORRTHERM element at Allied Metal Treating Corporation, Kenosha, Wisconsin. This furnace is used 24 hours a day, 6 days a week, for carbonitriding, clean hardening pinion gears, hardening crank shafts after carburizing and carburizing small gears and shafts.

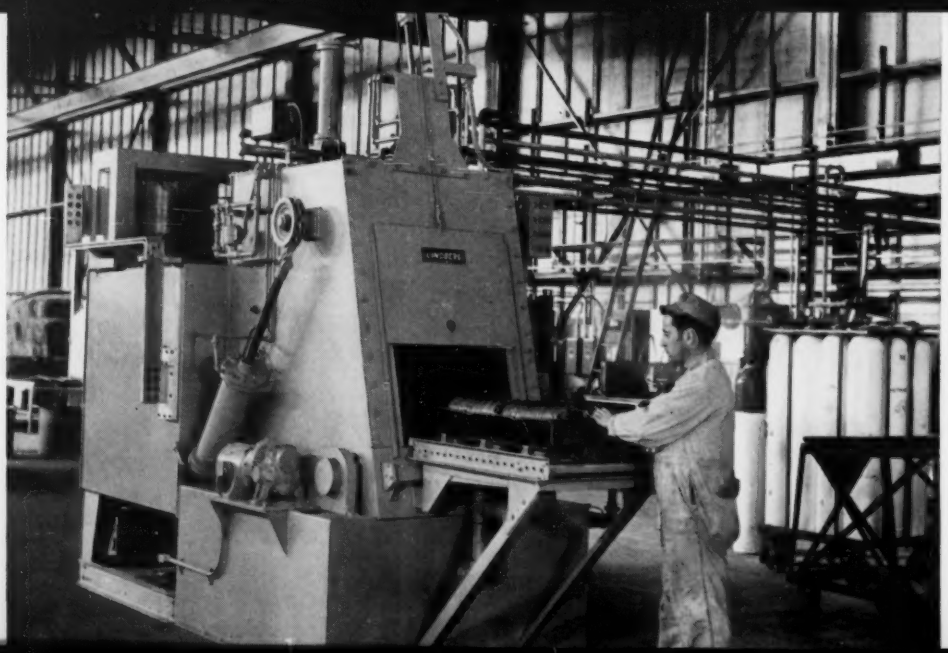
EKLUND

Installation of new Lindberg furnace with CORRTHERM electric element at Eklund Metal Treating, Inc., Rockford, Illinois. Furnace used 24 hours a day, 7 days a week, for carburizing gears and machine tool parts, carbonitriding sheet metal screws and automotive parts, and hardening and tempering bolts.



PERFECTION

Lindberg electric furnace with CORRTHERM element just installed at Perfection Tool & Metal Heat Treating Company's Lombard, Illinois plant. This furnace is being used 24 hours a day, 6 days a week, for carbonitriding and carburizing parts for automotive and farm implement industries.



COMMERCIAL HEAT-TREATERS QUICK TO ADOPT LINDBERG ELECTRIC CARBONITRIDING FURNACES WITH NEW CORRTHERM HEATING ELEMENT

It is significant that commercial heat-treaters, always in the lead in the acceptance and development of better heat-treating methods, have been among the first to appreciate the revolutionary advantages of Lindberg's newly announced CORRTHERM electric heating element.

Recent Lindberg CORRTHERM-equipped furnace installations in plants of three leading midwestern commercial heat-treaters are shown on the opposite page.

Where electricity is the preferred source of heat Lindberg furnaces with CORRTHERM provide to the fullest degree the versatility and dependability required in efficient commercial heat-treating. Ideal for carbonitriding, they are readily applicable to other processes—carburizing, carbon restoration, bright hardening or annealing, and normalizing.

Whether your heat-treating operations are commercial or captive, large or small, the CORRTHERM element in Lindberg electric furnaces offers you these exclusive advantages:

Low voltage—operates at extremely low voltage. No leakage through carbon saturation.

Atmosphere Circulation—elements act as baffle to direct circulation of convection streams.

Safety—extremely low voltage eliminates shock or short hazards.

Durability—watts density at all time low. Element practically indestructible.

This shows how the new Lindberg CORRTHERM electric heating element fills the furnace with walls of glowing heat. Note also that CORRTHERM is conveniently hung from simple brackets requiring no complicated connections or construction.

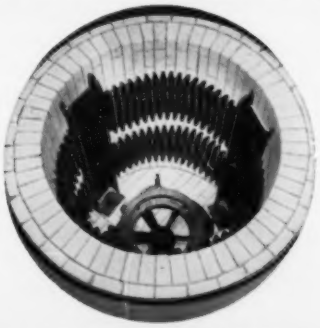
CORRTHERM is an exclusive Lindberg development created in Lindberg laboratories by Lindberg metallurgists and engineers. To find out how its advantages can be applied to your heat-treating processes consult your nearest Lindberg Field Representative. (Look in classified phone book.)

LINDBERG ENGINEERING COMPANY

2466 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 Regentview Ave., at Downey, California

Installation of CORRTHERM elements in one of two large rotary furnaces just erected in the field by Lindberg's associate company, Lindberg Industrial Corporation.



Installation of Lindberg CORRTHERM-equipped carburizing pit-type furnace in plant of Lindberg Steel Treating Co., Melrose Park, Ill.

Safety! Extremely low voltage makes CORRTHERM elements completely safe. Let operator or work load bang it if they will. Neither element nor operator will be hurt.

MANUFACTURERS' LITERATURE

For your copy circle the number on the Readers' Service Card

ABRASIVE SEPARATORS

The importance of proper blast cleaning abrasive separation to efficient cleaning room operations is emphasized in a new 8-page booklet recently issued by the Pangborn Corporation, Hagerstown, Md.

Four types of separators are described which handle from 33,000 to 320,000 lb/hr of abrasive.

Fifteen photographs and drawings illustrate the principles of operation and the types of equipment available.

For further information circle No. 6

MOVING MATERIALS

Lamson Mobilift Corporation, Portland, Oregon, announces the release of a new six-page, file-size bulletin, "MOVE MATERIALS".

There are five photo cuts with thumb-nail descriptions of some of the exclusive cost-reducing features of the stand-up and sit-down models, tables of complete specifications of each model and a page of two color sketches showing twelve of the Mobilift matched attachments.

For further information circle No. 7

INDUSTRIAL RADIOGRAPHY

A new 4-page bulletin available from Metal & Thermit Corporation, New York, N. Y., describes the new Kel-Ray Projectors for industrial radiography with gamma rays. The projectors are available in three sizes and offer a choice of radioactive isotopes of different intensity.

The text covers the types of spot, hemispheric and panoramic radiographs that may be made, tells how the projectors are positioned for different applications and explains the safety features provided to guard against damage from fire, water, sudden shock and tampering.

For further information circle No. 19

STEEL HEAT ABSORPTION

"The Rate of Heat Absorption of Steel" is the subject of a new 32-page booklet being distributed by Bloom Engineering Company. The brochure details a simplified method by which the heating rate of steel can be calculated and the center temperature of the piece predicted. Included are 15 charts and diagrams.

For further information circle No. 8

HEAT TREATING EQUIPMENT

A new catalog of descriptive fact sheets bound in convenient file folder form is available from Sargent & Wilbur, Inc., Pawtucket, R. I. Contents give details on S & W heat treating furnaces and atmosphere generators, both electric and fuel fired.

Described and illustrated are exothermic and endothermic generators, ammonia dissociators, sulphur towers, dryers, tool hardening and tempering furnaces, shaker hearth furnaces, horizontal conveyor furnaces, inclined hood conveyor furnaces, pusher furnaces, strip annealing furnaces, car bottom furnaces, available S & W accessories and miscellaneous equipment. High temperature furnaces made to order. Specifications are stated, along with notes on special advantages and other important features.

For further information circle No. 9

HIGH FREQUENCY COMBUSTION UNIT

A new bulletin fully describing a high frequency combustion unit for rapid determination of total sulfur in diesel fuel, kerosene, oil sludges, lubricating oils, lubricating oil additives, tars, asphalts, spent caustics, catalists, and other inorganic materials has been issued by the Laboratory Equipment Division of Lindberg Engineering Company.

The method used for determining total sulfur in petroleum product is outlined including specifications and a listing of accessories to comprise a package unit.

For further information circle No. 10

MOLYBDENUM SILICIDES

Two new companion publications on molybdenum silicides have just been issued by Climax Molybdenum Company, New York, New York.

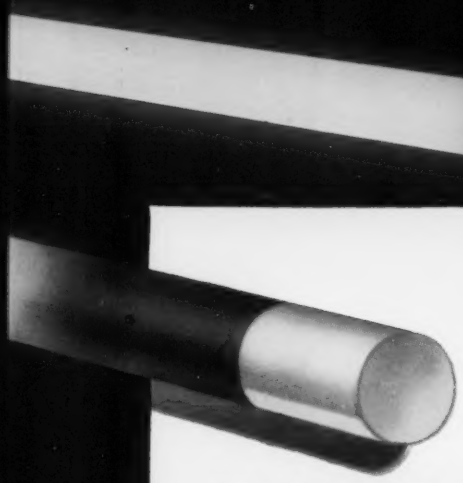
In Refractory Molybdenum Silicides, complete information on the various molybdenum silicides is consolidated from 52 reference sources. This includes preparation, applications, and chemical, physical and mechanical properties of this new class of refractory compounds. In addition, multisilicide systems — e.g., chromium silicide-molybdenum silicide systems; titanium silicide-molybdenum silicide systems; etc. — are covered.

These molybdenum silicide compounds are characterized by outstanding resistance to oxidation and corrosion and superior stress-rupture strength at high temperatures. Of the various stable silicides, the disilicide ($MoSi_2$) seems to be the most interesting. It is unaffected by most inorganic acids including aqua regia; resists oxidation up to 1700°C; and at 980°C has a 100-hour stress-rupture strength superior to cemented carbides.

For further information circle No. 11

(Continued on page 41)

the heating elements that last up to three times longer!



...and these are the advantages "Hot Rods" bring to your production

Savings In Element Costs — Because you use far less of them. Many plants report "Hot Rods" outlast other nonmetallic heating elements — *up to 3 to 1!*

Lower Maintenance Costs — Using less "Hot Rods" means less time spent in replacements and voltage tap changes. And there is an additional saving. You don't have to shut down your furnace or kiln to replace elements.

Better Product Quality — "Hot Rods" heat more uniformly because of their slow, evenly matched rate of resistance increase. This helps to protect product quality and to maintain the smooth flow of production, with fewer rejects.

Fast Service — You can get "Hot Rods" on short notice, if necessary, shipped from adequate stocks. And they're packed shockproof to reach you unbroken.

Typical "Hot Rod" Applications

Brazing operations on copper, silver, etc. . . . heat treating high speed steel . . . steel hardening . . . bright annealing of stainless steels . . . bright cleaning (deoxidizing, degreasing, etc.) . . . sintering powdered metals . . . heating for forging . . . metal melting . . . ore refining.

For further facts on how "Hot Rods" can improve and reduce the cost of your own electric furnace operations, send for the booklet "Norton Heating Elements." NORTON COMPANY, Refractories Division, 624 New Bond Street, Worcester 6, Mass.

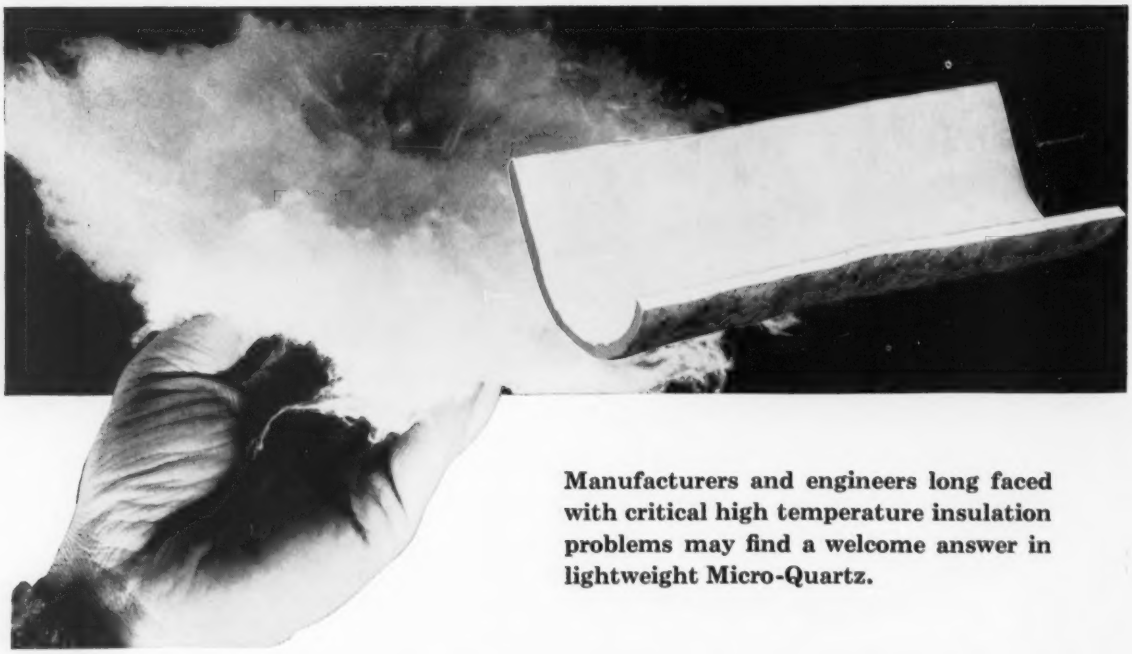
NORTON®
REFRACTORIES
Engineered... Rx ... Prescribed

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

Making better products . . . to make your products better

L·O·F Glass Fibers Company Introduces

MICRO-QUARTZ—The new insulation for the 2000°-2500° Temperature Range!



Manufacturers and engineers long faced with critical high temperature insulation problems may find a welcome answer in lightweight Micro-Quartz.

L·O·F Glass Fibers Company announces Micro-Quartz—a remarkable, new insulation for temperatures ranging, under many conditions, up to 2500°!

Micro-Quartz is available in felted form and in bulk. It is light in weight and composed of 98% pure quartz. It is resilient, exceptionally efficient, and resistant to vibration and air flow. Because it has no organic binder, its performance, stability, and thermal conductivity are those of the quartz fibers themselves.

The range of uses to which Micro-Quartz can be put is very broad, with possible applications in all industries doing work in the high-temperature field. It may be the answer to high temperature problems involving low heat capacity and high thermal diffusivity, frequent- or rapid-heating cycles, and problems of weight, space limitations, and vibration.

Micro-Quartz fibers are available in paper form. Can be impregnated or coated for electrical applications.

Requests on your business letterhead for more information, and a Micro-Quartz sample, will receive prompt attention. Write: L·O·F Glass Fibers Company, Dept. 89-66, 1810 Madison Ave., Toledo 1, Ohio.

PRODUCT DATA ON STANDARD MICRO-QUARTZ SHEETS*

Average Fiber Diameter—0.75 microns or 0.00003 inches

Density—Standard nominal density is 3 lbs./cu. ft.

Weight—0.047 lbs. per sq. ft.—0.005 lbs.

Thickness of sheet—Standard nominal thickness is 3/16 inches

Width of sheet—34 inches

Length of sheet—71 inches

*Other thicknesses and densities are available. Sheets can be fabricated to fit your application.

LOF GLASS FIBERS Micro-Quartz HIGH TEMPERATURE INSULATION

L·O·F GLASS FIBERS COMPANY

TOLEDO 1, OHIO

Makers of glass fibers by the exclusive "Electronic-Extrusion" process

MANUFACTURERS' LITERATURE

(*Continued from page 37*)

EQUIPMENT FOR INDUSTRY

A new 31-page catalog has been issued by Salem-Brosius, Inc., Carnegie, Pa., describing the various equipment for industry which they design and build.

The illustrated brochure describes the many-sided activities and experience that the company has had in the design, engineering, and construction of furnace and mechanical equipment for industry.

The catalog is divided into the following subdivisions: heating furnaces; heat treating furnaces; special mechanical equipment; materials handling equipment; and water purification processes.

For further information circle No. 12

CARBURIZING FURNACE

An article which appeared in an issue of METAL TREATING on the subject of "Versatile Carburizing Furnace Pays for Itself in 4 Years," and which was written by W. H. Weinwurm, Chief Metallurgist of the Union Special Machine Company of Chicago, Ill., is now available as a reprint from the Ajax Electric Company, Philadelphia, Pa.

The reprint explains how this Ajax electrode-type salt bath carburizing furnace paid for itself in 4 years by reduced maintenance costs.

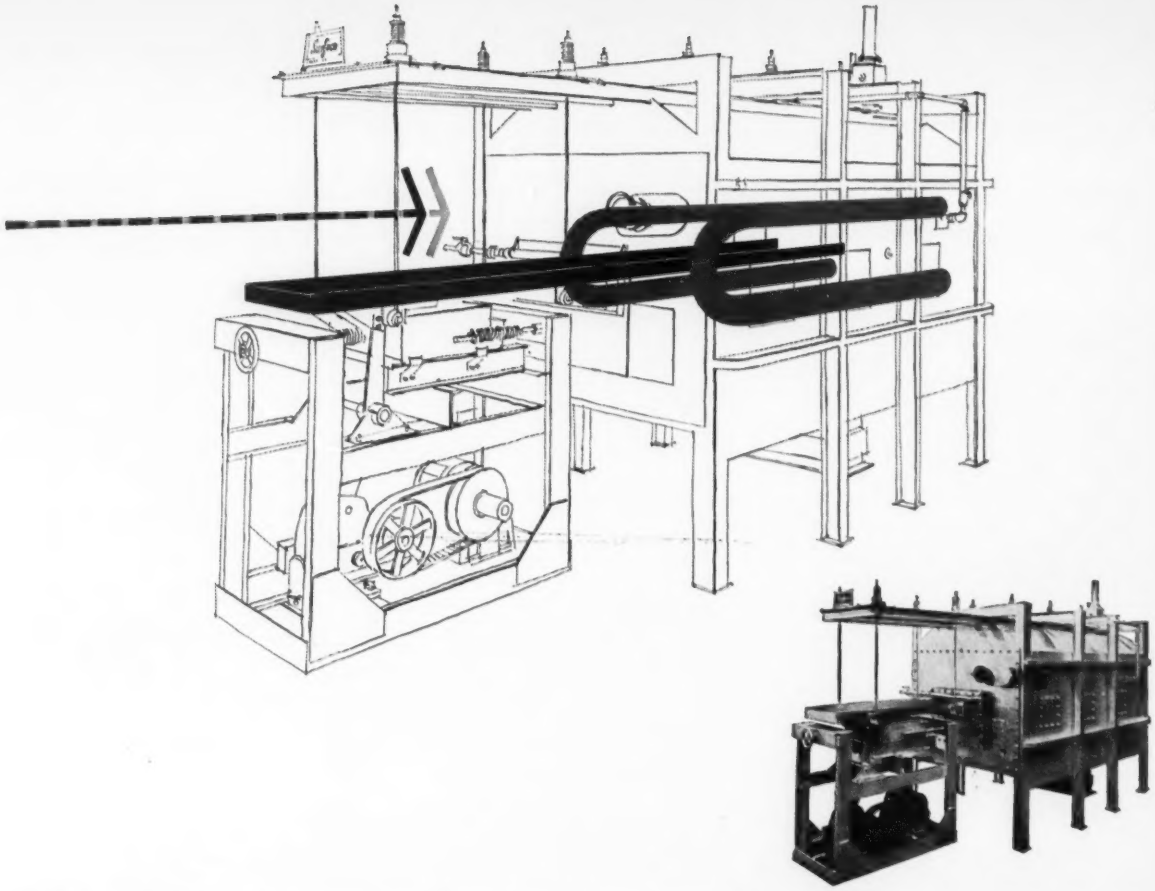
For further information circle No. 13

MEASUREMENT EQUIPMENT CATALOG

Eighty different devices are covered in a 40-page "testing-instruments reference book" just published by General Electric's Instrument Department.

The catalog contains complete product information including applications, sources of additional information and pictures. Ranging from simple thickness gages to the mass spectrometer leak detector, there are instruments for research, production, laboratories and educational use. Measurement categories include color, leak detection, insulation, and radiation monitoring.

For further information circle No. 14



New furnace puts "snap" in small parts production

The quantity and quality of small parts can be increased by controlled atmosphere heating and quenching in this new Surface® Snap Hearth Furnace. Production rates up to 300 lbs/hr are being attained in many plants.

This is the first suspended hearth furnace to use suction type radiant tube firing, which eliminates a muffle and its replacement problems. Another important feature is the hearth, which snaps to move the parts a short distance at regulated intervals. Hopper loading can be easily applied to the furnace.

Combined with Surface atmosphere generating equipment, the Snap Hearth Furnace is especially efficient for clean hardening, dry cyaniding, carbon restoration. In several plants, the furnace is part of completely automatic hardening-tempering lines.

Snap up your small parts production; ask your Surface man to show you how the Snap Hearth Furnace fits your plant.

Send for Bulletin SC-173. Surface Combustion Corp., 2381 Dorr St., Toledo 1, Ohio.

SURFACE COMBUSTION CORPORATION

Also makers of Janitrol® automatic space heating and Kathabar® humidity conditioning units

Surface®
HEAT TREATING EQUIPMENT

NEWS TO HEAT TREATERS

(Continued from page 20)

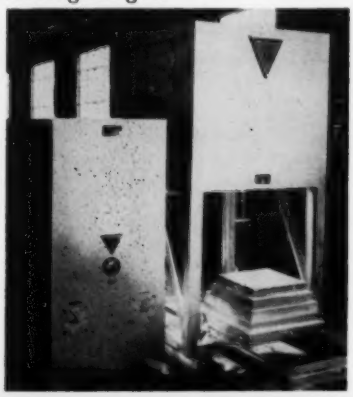
vents skin contact with external irritants normally encountered in industry. In actual use, through an extensive development period prior to general release, it proved extremely effective against irritants known to cause dermatitis, skin rash, skin drying and cracking. It is equally effective for wet or dry work and retains its protective powers even when skin is immersed in liquids for long periods.

For further information circle No. 15

ELEVATOR-TYPE ELECTRIC FURNACE

A new, high-temperature inverted pit-type furnace, known as Model IP-6700, has just been announced by the Pereny Equipment Company, 893 Chambers Road, Columbus 12, Ohio. It is provided with a vertical lift or elevator-type closing arrangement which permits the door, when lowered, to serve as a hearth that may be rolled to the front of the unit in an accessible convenient location. This makes the unit adaptable to a wide variety of usage, especially where work to be handled involves extremely heavy parts such as steel dies or crucibles containing molten glass or metals. The parts are easily loaded onto the hearth or door which is then rolled on tracks back to position and raised to the pit-type work chamber.

The manufacturer also reports that by this method of bottom loading a much closer gradient is achieved than is possible with the more conventional front or top loading designs.



The chamber size of this Pereco Electric Furnace is 18" wide x 18" deep x 21" high. The hearth or car top, which serves as the closure, measures 18" wide x 18" deep. The unit's over-all size is 39" wide x 48" deep x 90" high. Raising of the hearth, which will take a work load of approximately 150 lbs., is by a safety hand ratchet (power lift equipment is optional).

This new unit, incorporating silicon carbide heating elements, has an operating temperature up to 2750°F., with a heat-up period (to maximum) of three to four hours.

For further information circle No. 16

AIR-GAS BURNER SHELLS

Greatly increased service life is reported by Selas Corporation of America, Philadelphia, Pa., for burner shells of Selas "Superheat" air-gas burners as the result of using Inconel in their construction.

The studies were made in connection with burners used in auto-

matic machines for localized flame hardening and brazing. In this application, heat transfer to the work is accelerated by a super-hot stream of burned gas, which issues from the burner nozzle at a speed and temperature usually associated with jet engine operating conditions. Thermal impact is so high that some products can be heated, formed and delivered by the jet action.

The frequency with which burnouts were occurring when another high temperature alloy was specified, led Selas to initiate a search for better materials. Since high strength at elevated temperatures was a primary requirement, Selas eventually selected Iconel for this service.

Improved performance was apparent in less than a month. The Inconel shells have delivered a minimum of 500 hours of service. When the former material was used, burnouts occurred in a fraction of that time.

For further information circle No. 17

CRUCIBLE STEEL PERSONNEL CHANGES

Wm. P. Snyder, Jr., Chairman, Crucible Steel Company of America, has announced to the Company's Board of Directors his desire to be relieved of the active management of the Company's affairs, a position he has held since 1944.

At the Company's annual organization meeting later this month Crucible's president will become its chief executive officer. At that time, Joel Hunter, President since May, 1954, will assume the responsibilities of the general management of Crucible's activities.

7 S&W Furnaces at SPERRY RAND

In the Sperry Electronic Tube Division of SPERRY RAND, Gainesville, Florida, a battery of 7 Sargeant & Wilbur furnaces perform faithfully and economically, aiding in the production of klystron tubes.

● Five S&W Conveyor Furnaces with 15" belts are used for silver and copper brazing of klystron tube components, as well as for degassifying and oxidizing.

Two S&W Pusher Furnaces are used primarily for brazing operations.

Atmosphere is dissociated ammonia, produced from two 2,000 CFH S&W Ammonia Dissociators.

Purging atmosphere is supplied by a 1500 CFH Forming Gas Generator. This atmosphere is dried by an automatic, activated alumina dryer.

Write today for literature—and state your problem. Our staff of engineers is ready to advise without obligation.

Representatives

WM. D. PRICE
611 Ann Street — Box 414
Monroe, North Carolina

JOHN FIGNER CO.
1123 LaClaire Ave.
Pittsburgh 18, Pa.

ROY M. JAHNEL
1095 Conn. Ave., N.W.
Washington, D. C.

M. CLAYTON SCHWER
2920 Grand Blvd.
Detroit, Michigan

WM. G. PRAED
416 N. State St.
Chicago 10, Ill.

T. C. JARRETT CO.
95 South Ammons St.
Denver 15, Colorado

EDWIN A. WERT
1828 N. Alexandria Ave.
Los Angeles 27, Calif.

GERALD B. DUFF & CO.
2165 Morris Ave.
Union, New Jersey

STOUT & LOMAN
712 West Sycamore St.
Kokomo, Indiana

MARSHALL C. BATTEY
180 Weeden St.
Pawtucket, R. I.

C. R. MORELLO
Crestmont Products, Ltd.
45 Hollinger Road
Toronto 16, Ontario

SARGEANT & WILBUR, INC.
185 Weeden St., Pawtucket, R. I.

Complete Line of Electric and Fuel Fired Heat Treating Equipment • Furnaces • Generators • Ammonia Dissociators Gas Conditioning Equipment • Accessories

At the request of the Board of Directors, Mr. Snyder will continue as Chairman, presiding at meetings and acting in an advisory capacity.

Mr. Hunter joined Crucible in 1951 as vice president in charge of finance. He was elected a director and executive vice president in 1953. He succeeded to the office of president in May, 1954. Previous to joining Crucible he was a partner in Haskins and Sells, Crucible's independent auditors, and as such devoted a considerable amount of his time to Crucible affairs.

NEW SALES MANAGER

Sargeant & Wilbur, Inc., has announced the appointment of Mr. Morris Wm. Jones as its General Sales Manager. Mr. Jones, a graduate of Stevens Institute of Technology, comes to the Pawtucket, R. I. firm after many years of experience in engineering, research and sales management. He has been associated with the Gulf Oil Corp. and C. I. Hayes, Inc.

VERSATILE FURNACE

A new radiant tube, clean hardening furnace has been announced by Standard Fuel Engineering Company, Detroit, Michigan.

The unit is recommended not only for clean hardening, but also for annealing, carburizing and for other atmosphere work.

Features of the unit are vertical alloy radiant tubes which are easily replaced from the top of the furnace. A high velocity alloy fan, for recirculating the atmosphere, is located in the roof of the unit.

Through the use of roller chains and sprockets, the door is raised and lowered from a drive located at the base of the furnace. The door, although fully sealed with asbestos gaskets, is in addition inclined to provide a natural friction seal. A gas curtain is provided and its operation is automatic upon opening of the door.

The unit is available as a complete package with all electrical equipment such as motors, starters and limit switches wired to a common inlet. The burners and pilots are manifolded together for air and gas connections.

For further information circle No. 18

METAL TREATING

EQUIPMENT and MATERIALS DIRECTORY

AGITATORS

J. P. DEVINE MANUFACTURING CO.
49th Street and A. V. R. R.
Pittsburgh 1, Pennsylvania

★ ★ ★

HEAT TREATING FIXTURES

E. J. CODD COMPANY
700 S. Caroline Street
Baltimore 31, Maryland

GENERAL ALLOYS COMPANY
367-405 West First Street
Boston 27, Massachusetts

INTERNATIONAL NICKEL CO., INC.
67 Wall Street
New York 5, New York

MISCO FABRICATORS, INC.
1999 Guoin Street
Detroit 7, Michigan

THE PRESSED STEEL COMPANY
Wilkes-Barre, Pennsylvania

ROLOCK INC.
1232 Kings Highway
Fairfield, Connecticut

STANWOOD CORP.
4825 W. Cortland St.
Chicago 39, Ill.

WIRETEX MFG. CO., INC.
16 Mason Street
Bridgeport 5, Conn.

★ ★ ★

CLEANING EQUIPMENT

PANGBORN CORPORATION
Hagerstown, Maryland

★ ★ ★

FABRICATION (Heat & Corrosion Resistant)

WIRETEX MFG. CO., INC.
16 Mason Street
Bridgeport 5, Conn.

★ ★ ★

FURNACES

AMERICAN GAS FURNACE CO.
808 Lafayette Street
Elizabeth, New Jersey

DENVER FIRE CLAY COMPANY
2301 Blake Street
Denver, Colorado

DOW FURNACE COMPANY
12045 Woodbine Ave.
Detroit 28, Michigan

ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street
Rockford Illinois

HEVI DUTY ELECTRIC COMPANY
Milwaukee 1, Wisconsin

INDUSTRIAL HEATING EQUIPMENT CO.
3570 Fremont Place
Detroit 7, Michigan

IPSEN INDUSTRIES, INC.
717 S. Main Street
Rockford, Illinois

LINDBERG ENGINEERING CO.
2466 W. Hubbard Street
Chicago 12, Illinois

PERENY EQUIPMENT CO.
893 Chambers Road
Columbus 12, Ohio

SARGEANT & WILBUR, INC.
185 Weeden Street
Pawtucket, Rhode Island

SURFACE COMBUSTION CORPORATION
HEAT TREAT DIVISION
Toledo, Ohio

★ ★ ★

FURNACES (Salt Bath)

AJAX ELECTRIC CO.
940 Frankford Avenue
Philadelphia 23, Pa.

THE A. F. HOLDEN CO.
14341 Schaefer Highway
Detroit 27, Mich.

★ ★ ★

GASES

ALLIED CHEMICAL AND DYE CORP.
NITROGEN DIVISION
40 Rector Street
New York 6, New York

ARMOUR AND COMPANY
AMMONIA DIVISION
1355 W. 31st Street
Chicago, Illinois

★ ★ ★

GAS GENERATORS

HEVI DUTY ELECTRIC COMPANY
Milwaukee 1, Wisconsin

LINDBERG ENGINEERING CO.
2466 W. Hubbard Street
Chicago 12, Illinois

SARGEANT & WILBUR, INC.
185 Weeden Street
Pawtucket, Rhode Island

★ ★ ★

HEATING ELEMENTS (Non-Metallic)

HORTON COMPANY
Worcester 6, Massachusetts

★ ★ ★

NITRIDING

UNITED STATES STEEL CORP.
OIL WELL SUPPLY DIVISION
Oil City, Pennsylvania

★ ★ ★

IMPREGNATION EQUIPMENT

J. P. DEVINE MANUFACTURING CO.
49th Street and A. V. R. R.
Pittsburgh 1, Pennsylvania

METAL FINISHING

ARTHUR TICKLE ENGINEERING WORKS, INC.
23 Delevan Street
Brooklyn, N. Y.

★ ★ ★

QUENCHING OILS

E. F. HOUGHTON & CO.
303 W. Lehigh Avenue
Philadelphia 33, Pennsylvania

PARK CHEMICAL COMPANY
8076 Military Avenue
Detroit 4, Michigan

SHELL OIL COMPANY
50 West 50th Street
New York 20, New York

SUN OIL COMPANY
Industrial Products Department
Philadelphia 3, Pa.

★ ★ ★

REFRACTORIES

DENVER FIRE CLAY COMPANY
2301 Blake Street
Denver, Colorado

NORTON COMPANY
Worcester 6, Mass.

★ ★ ★

SALTS

ALLIED CHEMICAL AND DYE CORP.
NITROGEN DIVISION
40 Rector Street
New York 6, New York

AMERICAN CYANAMID COMPANY
METAL CHEMICALS SECTION
30 Rockefeller Plaza
New York 20, New York

THE A. F. HOLDEN CO.
14341 Schaefer Highway
Detroit 27, Mich.

E. F. HOUGHTON & CO.
303 W. Lehigh Avenue
Philadelphia 33, Pennsylvania

PARK CHEMICAL COMPANY
8076 Military Avenue
Detroit 4, Michigan

★ ★ ★

STRAIGHTENING EQUIPMENT

GENERAL MANUFACTURING COMPANY
6437 Farnsworth
Detroit 11, Michigan

★ ★ ★

TEMPERATURE CONTROLS

IPSEN INDUSTRIES, INC.
717 S. Main Street
Rockford, Illinois

METAL & THERMIT CORP.
100 East 42nd Street
New York 17, New York

CLARK INSTRUMENT, INC.
10203 Ford Road
Dearborn, Michigan

★ ★ ★

TOOL STEELS

BETHLEHEM STEEL COMPANY
Bethlehem, Pennsylvania

CRUCIBLE STEEL COMPANY OF AMERICA
Pittsburgh, Pa.

INDEX TO ADVERTISERS AND THEIR ADVERTISING AGENCIES

star performer

...and among high speed steels

REX is the leader

Crucible REX® high speed steel has been the winner in shop tests for more than fifty years. *And now REX is even better than ever!* For Crucible research and experience has led to improved manufacturing techniques that mean higher quality – greater uniformity.

Prove the superiority of REX for yourself – on your next job. Check it for size, structure, response to heat treatment, all-around tool performance. Then you'll know why REX has always been the *standard by which other high speed steels are compared.*

REX is immediately available at all of Crucible's convenient warehouses – or through prompt mill delivery. For a list of available data on REX and other Crucible *special steels*, write for a free copy of the "Crucible Publication Catalog". *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

Heat treating with low drag-out..

Madison Wire Company anneals stainless steel wire

WITH AEROHEAT 1200

Heat Treating Compound

Here's what was needed: a heat-treating bath that would give trouble-free operation with low drag-out at the Madison Wire Company in Buffalo, N. Y. AEROHEAT 1200 was the answer.

Madison's high-quality stainless steel wire is put through four draws, then annealed in AEROHEAT 1200 for 20 minutes at 1450° F.

No carburizing or decarburizing of the wire occurs because AEROHEAT 1200 contains a built-in rectifier assuring neutrality of the heat-treating bath.

Low-cost, high-control annealing with AEROHEAT 1200 Heat Treating Compound may be job-right for your operation, too. For information or service, mail the attached coupon.

Cyanamid's heat treating compounds include:

AEROCARB® Carburizing Compound
AEROCASE® Case Hardening Compounds
AEROHEAT® Heat Treating Compounds

Other products for metal processing include:

AEROMET® Metallurgical Additive
Metallic Stearates
Surface Active Agents
Acids and other Heavy Chemicals

®Trade-mark

MT-6

AMERICAN Cyanamid COMPANY

METAL CHEMICALS SECTION
30 Rockefeller Plaza, New York 20, N. Y.

☐ Send data sheet on AEROHEAT 1200
☐ Have technical representative call

Name_____ Position_____

Company_____

Address_____

City_____ Zone____ State_____

In Canada: North American Cyanamid Limited, Toronto and Montreal